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Understanding Urban Travel Growth in the Greater Toronto Area: Volume I

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Understanding Urban Travel Growth in the Greater Toronto Area: Volume I

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Abstract: This report contains an investigation of morning peak period commuting patterns for workers employed in the central area of the City of Toronto (Planning District 1) based on the 1986 Transportation Tomorrow Survey (TTS) data. The analysis includes investigations of the temporal distribution of work trips to Planning District 1 (PD1), the relative importance of PD1 within the Greater Toronto Area (GTA) as a place of employment, spatial variations across the GTA in the dependency of residential zones on PD1 as a place of employment, and, in most detail, the spatial variations in work trip modal splits for PD1 destined trips.

Major findings of the study include: considerable consistency exists at the regional municipality level (outside Metro) in both the percentage of workers employed in PD1 (10%) and in their aggregate transit modal split (approximately 50%); distinct spatial patterns in PD1 dependency and transit usage for PD1 destined trips exist, however, at the local municipality the TARMS zone levels; 50% of all PD1 destined auto users originate within Metro Toronto (excluding the City of Toronto), while 25% of PD1 auto users originate within the City itself; similarly 50% and 35% of all PD1 transit users originate within Metro (excluding the City of Toronto) and the City, respectively; and policies designed to densify residential populations within Metro and the City along existing TTC travel corridors, to improve TTC service in currently under-utilized corridors, and to extend and improve GO-Rail services in the central area would, based on this analysis, all appear to possess potential for increasing transit usage into Toronto's central area.

Comments: Volume I (of 3 volumes) of the final report of Research and Development Branch Project 25194.

Key Words: modal split, central area work trip commuting, TTS database analysis, spatial variation in trip-making

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EXECUTIVE SUMMARY

The purpose of the research documented in this report is to investigate the temporal, spatial and modal patterns of work trip commuting into the central area of the City of Toronto using the 1986 Transportation Tomorrow Survey (TTS) as the database for the investigation. This work represents one component of a larger study funded by the Ministry of Transportation, Ontario (MTO) designed to achieve a better understanding of travel patterns within the Greater Toronto Area (GTA) as a basis for assessing alternative transportation policies for this large urban area.

In 1986 approximately one-fifth of all the home-to-work trips in the GTA were destined to the central area of the City of Toronto, generated by a workforce of 370,000. This central area is serviced by several transportation systems including a heavy rail subway, commuter rail, bus and streetcars, expressways and arterial roads. These numerous modes have created a varying spatial distribution of transport choices. Commuting patterns to the central area of Toronto now cover much of the 8700 km^2 within the GTA.

The tremendous growth occurring in the Greater Toronto Area has created levels of congestion that have led to alarm by many planners and leaders in the community. Many of the transportation systems that were initially planned and developed between the 1940's to 1960's are now reaching capacity and governments are having financial difficulty dealing with the situation. A clearer understanding of the transportation markets in the GTA, particularly to the central area, can only help in addressing these concerns.

The Transportation Tomorrow Survey, conducted in the fall of 1986, provides transportation planners in the GTA with the first database in 25 years that provides a comprehensive overview of travel behaviour throughout the GTA. Evolving transportation issues in the area can now be examined in a quantitative manner using the TTS database to a greater extent than was previously possible. This study provides one example of the use to which the TTS database can be put: the analysis of central-area based travel flows.

While distinct spatial patterns in the residential distribution of central area workers exist, the proportion of home-to-work trips destined to PD1 by regional municipality is extremely consistent. Approximately ten percent of each region's home-to-work trips are destined to PD1. The exception is Hamilton-Wentworth which presently has a minimal PD1 interaction. Outside of Metro Toronto, five local municipalities have significantly greater than the average 10% of their home-to-work trips destined to PD1. They are, in order:

Pickering	19%
Markham	16%
Oakville	16%
Mississauga	15%
Ajax	15%

Within Metropolitan Toronto this figure increases to 30%, in the City of Toronto to 50% and within Planning District 1 to 63%. Approximately one-third of the central area workers live in the City of Toronto and increasing numbers are choosing to live in the central area itself.

Approximately 15% of the commuters live more than 21 km from their PD1 employment (measured as a straight line distance) and five percent live more than 31 km from their place of employment.

Young women, approximately 25 years old, have the highest central area, home-to-work trip rate. The male rate peaks at approximately thirty years of age.

Modal choice variations amongst the central area commuters by region indicate that at the aggregate level of the regional municipalities modal opportunities are spatially equal. Distinct differences in mode choices are, however, obvious in a more detailed analysis. The overall mode split and number of trips being made by each mode for the Greater Toronto Area for home-to-work trips destined to PD1 are:

auto driver	30%	(95,200)
auto passenger	7%	(21,500)
transit	58%	(186,100)
walk	5%	(15,800)
cycle	1%	(2500)

Within PD1 the walk mode is the largest single mode of travel to work. Forty percent of the workers use this mode or 14,000 workers. Within the City of Toronto auto-based modes of travel tend to be more common in the east end, while overall 25,000 cars are driven to the central area daily by city residents travelling to work. Cycling registers a minor modal share in all areas of the city, with a 2% model share overall throughout the City.

Within Metropolitan Toronto 60% of PD1 commuters use transit. Auto use is higher along the Don Valley and adjacent to the 401 in Scarborough and Etobicoke. The largest area of consistently high transit use is the Willowdale and northern Don Mills areas of North York. Secondary high transit use areas are in southwest Scarborough and West Toronto. Several highly dependent transit zones have also developed adjacent to several subway stations.

Outside of Metro Toronto the mode splits in most of the regional municipalities is approximately:

auto driver	40%
auto passenger	10%
transit	50%

There are several pockets of higher transit use such as Oakville, Thornhill and Ajax.

Examining the origin of the commuters who arrive in the central area, by mode, three distinct groupings are evident:

- one in four cars entering the central area on home-to-work trips originated within one of the five regional municipalities
- the second of the four cars originated within the City of Toronto
- the final two of the four originated from the rest of Metro Toronto

Similarly for transit users:

- three out of twenty of the transit commuters originated within the five regional municipalities
- seven of the twenty from the City of Toronto
- the remaining ten from the rest of Metropolitan Toronto

Transit captivity, measured in terms of the commuter not having a driver's licence, increases with decreasing distance from PD1.

- fewer than 1 in 10 regional transit commuters are captive
- one in five Metro Toronto transit commuters are captive
- one in four City of Toronto transit commuters are captive

GO Train users are generally choice riders while 30% of the TTC's riders are captives.

The TTC also carries 87% of the transit riders to PD1 for home-to-work trips, while the GO Train carries most of the remaining 13%. There is a definite spatial division in transit property usage. This is with the exception of within Metro where the GO Trains obtain 20% of their riders from areas where generally most commuters still use the TTC.

The general policy implications of these findings are that transportation problems involving work trips to the central area can, at present, largely be addressed by looking at issues within the inner areas of the GTA. Small percentage changes in modal splits can have significant results in the number of automobiles using the roads. Several areas, particularly within Metro Toronto have relatively low rates of public transport use for trips to the central area. Addressing the transit needs of these areas could dramatically reduce road congestion in the central area.

Additional measures to curb the demand for roads to the central area include the densification of land uses at high transit use nodes. This is already occurring and possibly should be encouraged further.

To more completely understand the implications of these patterns it is essential that this work be repeated in a few years with new data (e.g., the proposed 1991 TTS update) and examine the differences that have occurred. This will provide a more profound understanding of the transportation needs in the GTA and provide some insight into how relationships with the central area are evolving. If the rate of growth in the central area declines, the spatial patterns may change. Mode choice may also be altered by declining PD1 dependence in the City, Metro Toronto or the regions. Equality of opportunity could alter female mode choices and trip rates.

In any future transportation study additional work should also be done with regard to auto passengers. Little is know about this mode. The choice mechanisms and the reasons for the consistency of usage of this mode across the GTA (approximately 7 to 8 percent of trips from all regions except Hamilton-Wentworth to PD1 use the auto passenger mode) remain unclear. The mix of informal and formal car pool formation should be investigated. This could lead to plans to encourage a more efficient use of auto pools to reduce the number of cars in the central area.

This report is the first of a three-volume set produced as part of the MTO-funded project "Understanding Urban Travel Growth in the Greater Toronto Area". Volume II presents an analysis of trip generation relationships within the GTA, while Volume III assesses future travel trends and their implications for transportation policies in the GTA.

CHAPTER 1

INTRODUCTION

1.1 Study Purpose

The purpose of the research documented in this report is to investigate the temporal, spatial and modal patterns of work trip commuting into the central area of the City of Toronto using the 1986 Transportation Tomorrow Survey (TTS) as the database for the investigation. This work represents one component of a larger study funded by the Ministry of Transportation, Ontario (MTO) designed to achieve a better understanding of travel patterns within the Greater Toronto Area (GTA) as a basis for assessing alternative transportation policies for this large urban area.

The GTA consists of Metropolitan Toronto and the five regional municipalities of Durham, York, Peel, Halton and Hamilton-Wentworth which, taken together, define the urbanized region at the western end of Lake Ontario and, in particular, the commuter shed for Toronto (see Figure 1.1). Tremendous growth has occurred, and is expected to continue to occur, in this region.

In 1964 the area population was 2.8 million, whereas today it is 4.2 million, and it is predicted to reach 5.3 million by the year 2001. [Ontario Ministry of Treasury and Economics, 1989] Much of the growth has occurred outside of the traditional urban area in the four generally suburban regions of Durham, York, Peel and Halton. This is analogous to the suburban sprawl that is occurring in many North American urban areas. Concurrent to this growth there has been significant redevelopment in the central area of the City of Toronto. Older areas have been gentrified, high density residential development has been built and commercial construction has flourished.

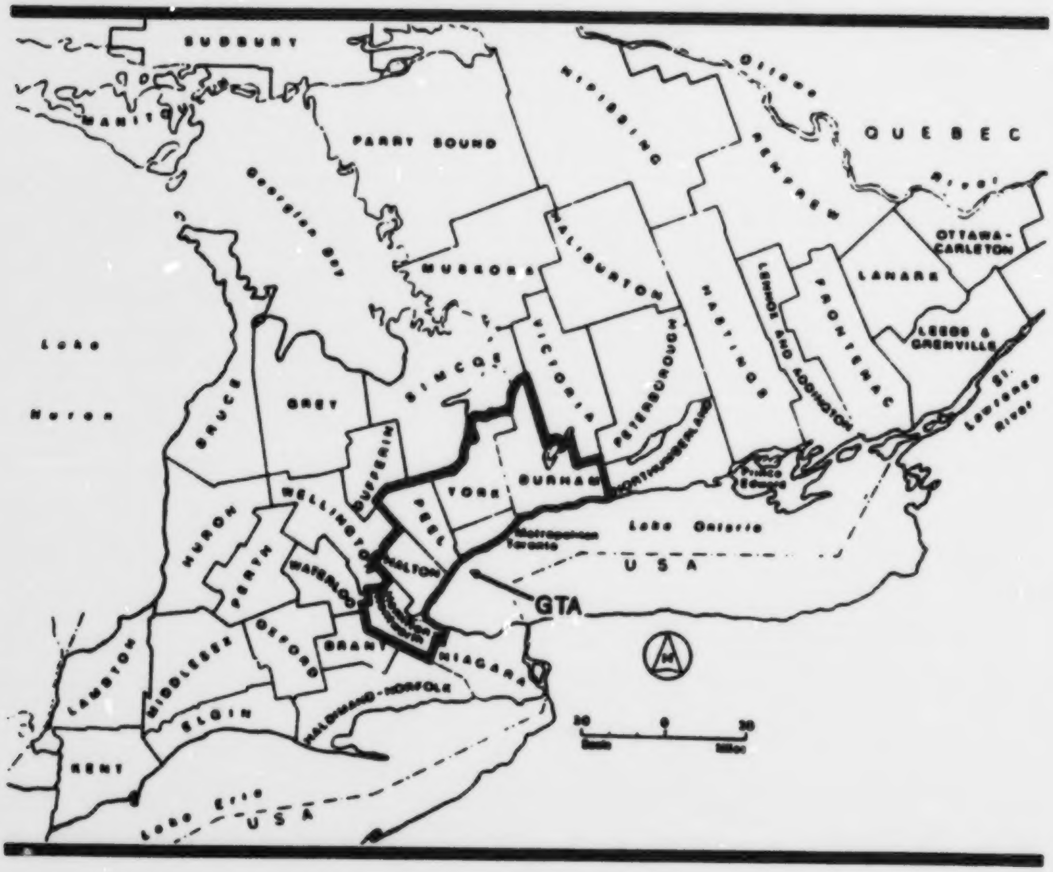

Figure 1.1 The location of the Greater Toronto Area (GTA) within Southern Ontario

In 1986 approximately one-fifth of all the home-to-work trips in the GTA were destined to the central area of the City of Toronto, generated by a workforce of 370,000[1]. This central area is serviced by several transportation systems including a heavy rail subway, commuter rail, bus and streetcars, expressways and arterial roads. These numerous modes have created a varying spatial distribution of transport choices. Commuting patterns to the central area of Toronto now cover much of the 8700 km^2 within the GTA.

The tremendous growth occurring in the Greater Toronto Area has created levels of congestion that have led to alarm by many planners and leaders in the community. Many of the transportation systems that were initially planned and developed between the 1940's to 1960's are now reaching capacity and governments are having financial difficulty dealing with the situation. A clearer understanding of the transportation markets in the GTA, particularly to the central area, can only help in addressing these concerns.

The Transportation Tomorrow Survey, conducted in the fall of 1986, provides transportation planners in the GTA with the first database in 25 years that provides a comprehensive overview of travel behaviour throughout the GTA. Evolving transportation issues in the area can now be examined in a quantitative manner using the TTS database to a greater extent than was previously possible.

This study provides one example of the use to which the TTS database can be put: the analysis of central-area based travel flows.

1.2 Report Organization

In addition to this brief introductory chapter, this report contains six chapters. Chapter 2 presents a brief review some of the literature dealing with the spatial distribution of central area commuters in large urban areas. While each urban area is unique in terms of its spatial layout and specific physical constraints, the overall differences and similarities in general patterns can, nevertheless, be examined. Chapter 2 discusses such characteristics, including the degree of containment within the central city, the effect of major road or transit transportation facilities and isolated commuter communities in relation to the central business area.

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[1] All data and figures in this report were produced using the TTS database unless otherwise stated.

Chapter 3 briefly reviews the Transportation Tomorrow Survey with respect to its survey methodology, the data obtained and data validity. The historical patterns of growth and the transportation infrastructure within the GTA are then described in Chapter 4. This lays a foundation for a detailed presentation in Chapter 5 of the spatial patterns of central area travel and mode choice which were obtained through analysis of the TTS database. The observed spatial patterns are compared with the theoretical constructs presented in Chapter 2 and the implications of the findings for transportation policy in the Greater Toronto Area are discussed in Chapter 6. Finally, Chapter 7 summarizes the major findings of this study and discusses directions for future work in this area.

This report is the first of a three-volume set produced as part of the MTO-funded project "Understanding Urban Travel Growth in the Greater Toronto Area". Volume II presents an analysis of trip generation relationships within the GTA, while Volume III assesses future travel trends and their implications for transportation policies in the GTA.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Transportation patterns in cities are largely dependent on the spatial structure of the city. This structure is unique to each urban area and is subject to local geography and patterns of growth. Few cities are directly comparable, but some clear similarities can still be drawn between large urban areas in North America. Similarly various theories of urban structure (and particularly of the role of central areas within urban structures) have been developed over time that serve as a conceptual foundation for our analysis of the travel patterns to the central area of Toronto. The purpose of this chapter is to review briefly some of these theoretical and empirical findings.

2.2 A Central Business District Definition

Initially it is necessary to decide which characteristics define the central area of a city. The central area has been defined as the core of the metropolis. Metropolis is derived from the Greek meaning "mother" and "city". The following discussion generally refers to large metropolis'. This is a collection of many cities, towns and townships focused on a principal urban centre. The population is generally greater than two million people.

The central business district (CBD) is usually within the original city of the urban area. It is on the main lines of transportation and thus theoretically easily accessible to most communities within the urban area. It therefore tends to be the area of the greatest travel intensity. [Hamburger, 1982] The central business district is generally surrounded by a larger "central area" for most planning purposes. Functions are attracted to the central area that serve the entire metropolis. Secondary functions that are unwilling to pay the premium associated with locating in the central area tend to vacate this zone. Therefore manufacturing, warehousing and some retail uses are not typically found in most central areas.

The displacing of secondary functions unwilling to pay the higher unit area costs associated with locating in the central area forces those functions that do remain to occupy fully built sites with multi-storey buildings. This gains the maximum value from the limited supply of land. The remaining land uses generally tend to be cultural, government, commercial and financial. Wolforth [1965] described the central business district in the following terms:

> *"Here one finds the greatest concentration of offices and retail stores, reflected in the city's highest land values and its tallest buildings. Here pedestrian travel on the streets reaches its maximum proportions. And, in one way or another too, the transportation net of the city, and that of a considerable area around the city, is oriented towards the CBD."*

Typically the smaller the overall urban area the greater the importance of the central area. This importance manifests itself as a more dominant centre for jobs, shopping, entertainment and other such functions. [Foley, 1952; Goodall, 1974] This indicates a certain economy of scale. As the city becomes larger, it is more likely that new subcentres will be developed to serve certain portions of the metropolis with central area type services. Therefore in most cities the central area does not continue to grow in employment, beyond a certain level, as the urban area grows. The proportion of the overall employment in the central area thus eventually starts to decline.

2.3 The Historical Evolution of Transportation in Cities

Most North American cities were originally built on a site of particular transportation advantage. Around this original site other areas were developed in relation to it. The nature of the original city centre and its relationship to its surrounding areas depends upon during which era of transportation it was developed. The oldest urban areas were based on pedestrian travel. Walking provided universal mobility within a limited range. The dense, compact urban area typically could grow to a maximum of ten kilometres in diameter, or ninety minutes walking time. [Vance, 1960]

The development of railways in the 1850's allowed easier access between satellite communities and central cities. Urban areas began to expand along the rail corridors. The directional growth was constrained by the number of rail lines leading into the urban area. The railways could only serve the communities immediately adjacent to their tracks. Rail technology is primarily suited for long distance transport because it is expensive and difficult to construct. The principal access mode to the new train stations was still by foot.

The "tentacle-like" nature of cities continued until the further refinement of rail based technology led to the development of the street railway in the 1890's. These railways could be built inexpensively along existing streets. The intricacy of the network that developed again allowed urban growth in potentially all directions from the existing urban area. Urbanization began to occur in much of the land that was close to the developed area but had been avoided because it was poorly served by the long distance railways. Cities rapidly expanded, subject to local geography. Commuters began to travel to the central core from all directions.

This pattern of development rapidly increased starting in the 1920's with the evolution of the automobile. Complete individual travel freedom again returned, as had been the case in the earlier period of walking. It was possible to travel almost anywhere within the city. The gaps between the urban area's tentacles could again be filled, but this time on a massive scale. It was now possible for the city to sprawl in all directions. Workers could now travel long distances on journeys at great speeds. Commuting distances thus greatly increased and continue to do so in most large urban areas.

2.4 Theoretical Central Area Travel Patterns

Several theories have been formed to explain residential distribution of central area workers in urban areas. Much of the latest research has concentrated on the growth of suburban employment which is one of the newest growth phenomena affecting urban areas. The older research was concentrated on central areas as they were initially the primary urban employment centre.

It is intuitively reasonable that workers will attempt to minimize the cost of work travel. That is, they will seek to minimize the distance or travel time between work and home. There is no intrinsic benefit to daily work travel nor does it produce personal economic gain. [Wolforth, 1965] It is also reasonable that central areas by their nature act as a focus for the whole metropolis, and, as an area which serves the whole urban regions they should draw workers from this entire urban area. This is contrasted with peripheral work locations which are traditionally assumed to draw workers from a more local area. [Wolforth, 1965; Carroll, 1952] Using both hypotheses one would thus theoretically expect the central area workers to be clustered about the central area, attempting to minimize travel distance, but be present, in lesser numbers, throughout the urban sphere. Travel time may also be minimized based on locational decisions related to the traditional presence of an elaborate transportation infrastructure leading to the central area. Using the basic concepts stated above, various hypotheses and models have been formulated by several researchers to explain the work trip travel patterns to central areas.

2.4.1 Vance

James Vance elaborated on ideas first stated by Kate Liepmann using the concept of zones of conflux and dispersion to describe the evolution of urban travel patterns. [Vance, 1960; Liepmann, 1944] Zones of conflux characterize locations were the primary land uses create employment while zones of dispersion are conversely areas primarily consisting of places of residence. This indicates the concept that certain areas attract workers (conflux) while other areas provide workers (dispersion). These concepts are then used to describe the entire evolution of urban areas and hence predict modern, central area, work trip, travel patterns.

The original siting factor for a city produced a zone of conflux around which the initial zones of dispersion were located. Increasing economic activity then leads to the expansion of the initial zones of dispersion. This growth has to be channelled, however, because the city is unable to grow in all directions simultaneously. This is because each doubling of the radius quadruples the area of the city and cities cannot normally expand at this rate. Thus growth occurs in selective areas and preferential land is used. These benefits are often based on transportation advantages.

As the city and the original zone of conflux expands it encroaches on the adjacent zones of dispersion. Some new commerce or industry is unable to locate in the zone of conflux and so produces a new zone of conflux outside of the original to meet its needs. Peripheral manufacturing zones are thus generated. As the city develops conflux zones displace more dispersion zones. New zones of dispersion then are produced successively further out from the original city.

This historical view is used to express the relationship between work locations and residence locations in cities. It is a logical description of the evolution of cities but lacks a clear reasoning for the modern distribution of workers about the central area that some of the other theories state.

2.4.2 Carroll

Carroll investigated the distribution of central business district workers. [Carroll, 1952] He reviewed the then current papers and reiterated the previously stated concepts describing the distribution of workers in urban areas. Carroll summarized three primary concepts discussed in the earlier research. Subject to geographic constraints, the total population of urban areas should be residentially distributed about the central area of the principal city. Secondly the residential distribution of people employed in the central area tends to approximate that of the entire urban area's population. Finally, in contrast to central area workers, residents who work in off-centre location tend to live closer to their workplaces. Therefore it can be stated that one would expect central area workers to also travel further to work than other workers.

One would also expect a constant declining density of central worker residences as distance increases from the central area. Central area workers would also approximate a fixed proportion of the residential population at successive distances from the centre of the city. This dominance of the central area employees throughout the residential area would lead to the downtown dominating the shape of the urban area. This is because the residential areas should all be oriented to the central area. An intensely concentrated city centre will lead to dense local residential distributions. In urban areas without a strong central area employment distribution, such as many industrial cities, this would lead to a much less dense residential distribution.

2.4.3 Park and Burgess

Robert Park and Ernest Burgess use different concepts to describe CBD-oriented residential areas. [Wolforth, 1965; Spreiregen, 1971] Their theories were based on social concepts, which they state are particularly applicable to twentieth century, North American cities. They see differences in social and economic characteristics occurring in concentric rings around the central area of the city. The characteristics of the housing and the people who live in this housing thus determines the propensity of people in those houses to take jobs in the central area.

In more detail, the central business district is an area of high land values and thus high density construction occurs. Businesses in this zone have sufficient revenues to pay these high rents. Beyond this district is a "zone of transition". This is the area where once well kept residences, from when the city was smaller, have deteriorated as prosperous owners moved outwards. This area then becomes the home for immigrants and the socially disadvantaged.

The next zone is a concentric ring of "workingmen's homes", a blue collar area. Once the centre of peripheral industry within the city, as the city grows this area is surrounded by residential homes. While some of the industry may have moved to the suburbs the homes in this zone generally remain primarily for blue collar workers and are oriented towards local industry. Beyond this zone is the band of "middle class residences". This is generally a white collar area which is oriented towards the central area. This band also contains satellite business centres and shopping areas which primarily serve the middle class market. Finally there is a "commuters' zone" or higher income area. Being on the periphery these workers have fewer local employment opportunities and tend to be more likely to commute downtown daily.

This theory conveys a declining population density with distance from the central area while dwelling unit value, the percentage of home ownership and household income increase with central area distance. The structure of the concentric theory is illustrated in Figure 2.1.

Park and Burgess indicate some general concepts but do not try to understand any of the locational or infrastructure effects that often radically alter the general case. They assume equal accessibility from all areas. In 1932 Babcock realized the importance of transportation corridors to the concentric theory proposed by Park and Burgess. He took the same theory and proposed distorting the concentric rings along these transportation corridors. Thus time to the CBD would be minimized rather than distance. The resulting pattern would tend to be axial, as is also illustrated in Figure 2.1. [Goodall, 1974]

2.4.4 Hoyt

The theory of Park and Burgess was also criticized by Homer Hoyt. [Wolforth, 1965] He felt Park and Burgess omitted several key factors which were determining residential location. Rail and water transportation lines attract industry regardless of the central area's location and therefore they are not necessarily on the periphery. Higher income homes also tend to favour the windward side of industry and higher altitude locations. High density residence areas with middle class occupants have also arisen in many downtown locations hence weakening the argument of the necessity for a zone of transition.

Hoyt proposed his own "sector theory", which is depicted in Figure 2.1. This theory is based on the transportation infrastructure radiating from the central area. [Goodall, 1974; Wolforth, 1965] He then proposed that specialization occurs in sectors away from the CBD rather than in concentric rings. The access associated with certain routes attracts certain land uses to those routes. For example, industry locates along one route into the CBD for particular commercial, political and transportation reasons and thus one sector is fixed.

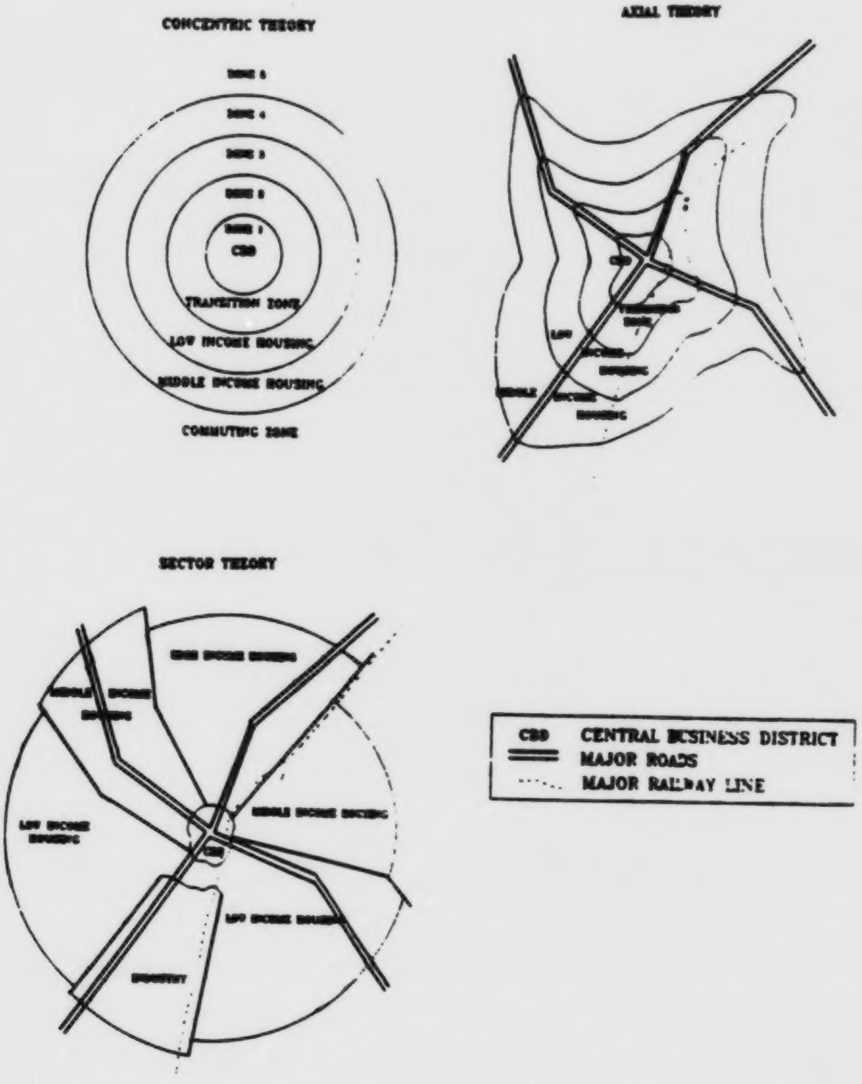


Figure 2.1 Theoretical Land Use Patterns [Goodall, 1974]

Next high income, CBD oriented housing locates along another transport route into the central area. This decision takes into account the location of industry and any geographic advantages. Medium income housing and lower income housing then fill in the other sectors according to their ability to compete for land. Lower income housing fills in the sectors which are the least desirable and on the leeward side of industry. Thus corridors of central area dependence are formed.

2.4.5 Prevedouros and Schofer

A theory linking residential location for CBD workers to the location of the CBD has been suggested by Prevedouros and Schofer. [Prevedouros and Schofer, 1988] Their study specifically addressed the causes and behaviour leading to suburban congestion, but in part addressed this issue. They classified Chicago suburbs into two groups, "stable suburbs" and "growing suburbs", according to growth and location, when looking at CBD workers.

Stable suburbs are largely developed and have little to no unused land. They are thus experiencing little or negative growth. These suburbs are generally adjacent or near to the city centre. They have a similarity or comparability with city centre neighbourhoods in terms of density, household size, income and occupations. Typical residence densities are between 3000 and 12,000 persons per square mile (1100 to 4600 person per km^2). These zones typically have above average transit service. Therefore a large proportion of these workers choose to work in the central city. In their study, Prevedouros and Schofer found that 34% of the resident workers in stable Chicago suburbs were employed in the central city.

Conversely, growing suburbs are characterized as having growing populations and employment and much more of a bias to auto-based modes of travel. The density of residential development is usually 2000 to 4000 persons per square mile (800 to 1500 person per km^2), and a much lower percentage of the workers in these zones typically work in the central city (e.g. 17% in Chicago).

Prevedouros and Schofer identify residential density as the key factor separating the two types of suburbs. The doubling of density in the older suburbs results in a more efficient (centrally oriented) transit system and a corresponding greater likelihood of central city travel.

2.4.6 Kain

Kain generated another central area residential distribution concept. [Kain, 1975] He stated that housing costs decline with distance from the city centre. Centrally employed workers can reduce housing costs by moving further out from the city, but this increases the commuting distance and travel time. One extends the distance one has to commute only as long as one's savings in rent offset the increased time and cost of commuting. He drew few conclusions relating to worker location beyond this point.

Kain only states the available CBD worker residential choices and the resulting modal implications. He extended his basic time-distance analysis to look specifically at reasons why people take transit into the central areas of cities. The use of public transit to the city centre depends upon historical antecedents, barriers or constraints to auto use which may be geographic or political and the intensity of downtown land use and employment.

According to his paper, the density of residential areas and workplaces will determine the level of transportation service provided and the door to door commuting time by competing modes. Only workers who live in areas with a certain person density can expect more than rudimentary transport facilities. There is also a high probability that a worker employed in a high density workplace, such as the CBD, and living in high density residential area will choose to take transit to work. If either or both the residence or workplace is of lower density, the probability of transit use declines.

The research was based on data from Chicago and Detroit. Chicago had an 80% transit mode split (1953), a high level of transit service and high downtown parking charges which discouraged auto use and stemmed from high worker densities. This is compared to a 53% transit mode split in Detroit where the worker densities were much lower and, as a result, the level of transit service was lower and the downtown parking was less expensive. Guest and Cluett [1976] also stated one of the strongest correlates of mass transit use was the age of the metropolitan area, particularly for work flows to the inner areas of the city. The structural characteristics of the older parts of the city encouraged transit use. Thus the link to the greater densities in the older areas is reinforced.

2.4.7 Gravity Models

Gravity models, which were first proposed by Ravenstein in 1885 with regards to migration, have been used to describe the relationship between the attraction of various zones. [Kanafani, 1983] These models are widely used to forecast spatial interaction patterns. Theoretically, they explain the difference in attractions between areas by asserting that the number of trips between, for example, zones "i" and "j" is proportional to the population in "i" and "j" and inversely proportional to the distance between "i" and "j" raised to some power. Population can be replaced with trips between the zones and distance can be replaced by travel time or any other selected impedance or friction between the zones. From the point of view of this study, however, the key concept associated with gravity models is that trips to the central area should decrease with increasing distance from the central area.

2.5 Specific Case Histories

Empirical findings from other North American cities where reviewed comparison with the results presented in Chapter 5 for the Greater Toronto Area. Most of this information, however, is either too old for elaborate comparison, described in too little spatial detail or from a city which is not overly comparable with Toronto. Further, most cities are spatially unique. Specific geographic or political features often predetermine the pattern of urban development, the extent to which various areas are related to central areas and the modal choices available to commuters. Despite these observations, however, results from two studies, one of Vancouver and one of Philadelphia, providing some interesting points of comparison to the Toronto case.

2.5.1 Vancouver

In Wolforth's analysis of the Vancouver area he found most of the previously discussed theoretical patterns to not be applicable. [Wolforth, 1965] The city neither produced concentric nor sectoral patterns. The study was performed in the mid 1960's when the population of the Greater Vancouver Area, was approximately 850,000.

He determined that the fundamental factor in residential growth was the creation of links across the numerous bodies of water bisecting the city. An example is the Lion's Gate Bridge, built in the 1930's, and the subsequent growth of West Vancouver. Secondary to this was the usurping of areas of natural beauty or geographic advantage such as the North Shore of Burrard Inlet or the Point Grey Peninsula of the City of Vancouver (the western half of the City) for exclusively higher income housing. The more expensive housing and limited availability for local employment led to many of these workers choosing to work in the central area of the City, which is north of False Creek. This was also the case in the "West End" of Vancouver. This is a high density residential area immediately west of the central area. The area east of Main St., in the City of Vancouver, (Main St., which runs north-south, roughly divides the City into two halves) was found to be much less CBD-dependent for employment even though many of the residents of this area lived extremely close to the central area. It was hypothesised that for these workers more intervening opportunities existed to find other jobs on any potential trip to the CBD. The distribution of central area workers in Vancouver, as described in this study, is illustrated in Figure 2.2.

One significant note was that Wolforth discovered that the public transportation system within Vancouver had played a minimal role in shaping the residential growth of the city into any specific corridors with superior downtown access times.

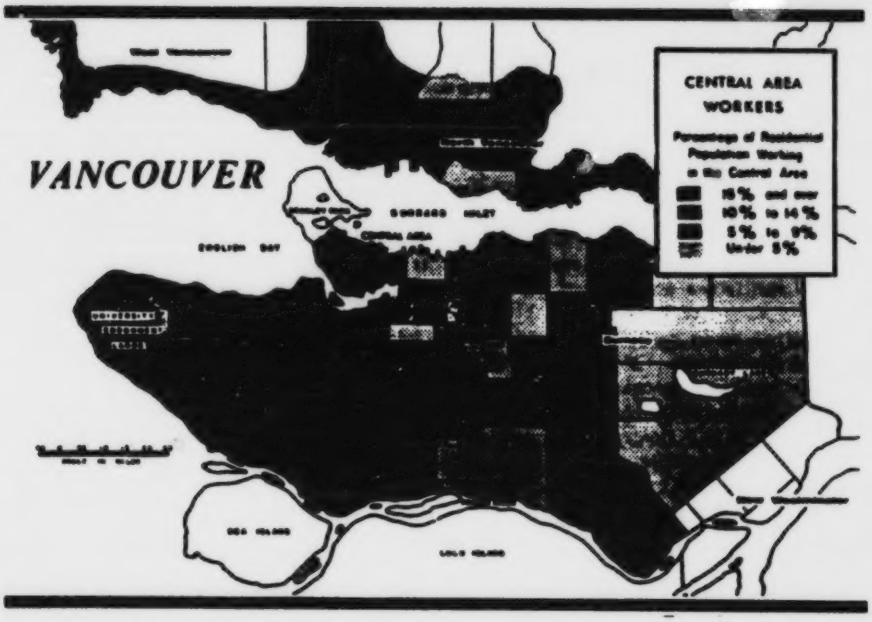


Figure 2.2 Distribution of Vancouver Central Area Employees, 1963 [Wolforth, 1965]

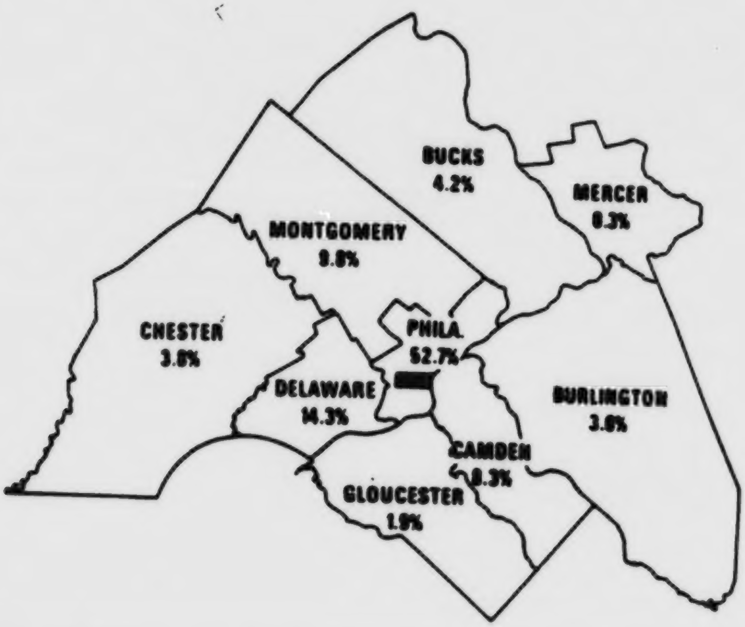


Figure 2.3 Center City Workers' County of Residence within the Delaware Valley Region (Philadelphia). The Center City area is indicated as black rectangle within the City of Philadelphia. [Zakaria, 1986].

2.5.2 Delaware Valley Region

An analysis of residential location and mode split for central area workers was performed for the Delaware Valley Region (Philadelphia and eight surrounding counties) in early 1985 and reported by Zakaria [Zakaria, 1986a, 1986b]. This is a 9800 km^2 area of 5 million people of which 1.7 million live in the 360 km^2 of the City of Philadelphia. Of the 236,000 workers in the Center City, 4.3% were sampled using a survey which was distributed through the workplace. The final usable sample, however, was only 1.8%.

It was found that 52.7% of the Center City jobs were held by residents of the City of Philadelphia. The political borders of the City of Philadelphia define an area approximately one-half the size of Metropolitan Toronto and thus it is not directly comparable with the values for the City of Toronto. Of the remaining commuters, 32.1% lived in the suburban Pennsylvania counties and the rest, or 14.1%, in suburban New Jersey. Thus, generally half of the jobs were held by urbanites and half by suburbanites. The distribution of Center City workers' place of residence, by county, is illustrated in Figure 2.3. (Note that Gloucester, Camden, Burlington and Mercer Counties are in New Jersey)

Overall 62% of CBD workers used transit modes for their trip to work. This was subdivided into 45% using bus, trolley, subway-elevated, sub-surface and the Lindenwold rail lines, and 17% using commuter rail. Redefining the results stated by Zakaria to match those used in TTS, 24% used the auto-driver mode and 8% were auto-passengers. Finally 4% walked to work and 2% used other modes.

CHAPTER 3

THE 1986 TRANSPORTATION TOMORROW SURVEY

The Transportation Tomorrow Survey (TTS) is a major transportation survey that was carried out in the Greater Toronto Area in the Fall of 1986 (mid-September to mid-December). The survey participants were the Ontario Ministry of Transportation, GO Transit, Metropolitan Toronto, the Toronto Transit Commission and the Regional Municipalities of York, Durham, Peel, Halton and Hamilton-Wentworth. Particular concerns that the survey was formulated to address were the reasons for trips, trip destinations, the modes used and the temporal distributions of trip start times. The process involved telephoning approximately 61,000 households over the survey period. Selected households were sent, via the mail, a personally addressed letter informing them that they had been selected for the sample and would be contacted later. The survey was also publicized in the local media using press conferences at each of the six regional government headquarters.

This survey was the largest travel survey carried out in the Toronto Area since MTARTS (Metropolitan Toronto and Region Transportation Study) in 1964. Little data had been collected in the interval between 1964 and 1976. The importance of travel data re-emerged in 1977 and public agencies in the GTA began to meet regularly to exchange planning information and to discuss data needs. This group was known as the TATPDCSC (Toronto Area Transportation Planning Data Collection Steering Committee). The individual agencies again started to collect data between 1977 and 1982 and then pool or share results through the TATPDCSC. The TATPDCSC soon began working toward an area-wide travel survey targeted for 1986. This would coincide with the national Statistics Canada Census which could be used for supporting data.

The survey was designed to consist of a 5% sample of the households in the GTA. Therefore, 125,000 households were selected, based on Bell Canada residential billing files.

According to the U.S. Bureau of Public Roads Guidelines, a recommended minimum sample for an area with approximately 1.5 million households, such as the GTA, is 4%. The final overall sample after rejections and households that were not able to be contacted was 4.1%. [MTO, 1987b]

TTS was the first time in the GTA that geocoding was used. The system allows addresses to be located to the nearest block face rather than solely by a traditional zone system. This makes the survey much more flexible, versatile and accurate as data can be aggregated to any zone system at a later date. Statistics Canada provided Area Master Files which could be used to convert street addresses to X-Y co-ordinates. This system could locate points to within one metre. For the survey's purposes addresses were located to the centre of the nearest blockface. For residential streets a point midway between intersections and 22m from the centre of the roadway was identified. Approximately half of the locations in the survey were so reported. [MTO, 1987b] Intersections were also located because in many cases (18%) specific addresses were not provided. A third class of location which were also located with co-ordinates were specific "monuments" so that common place names, such as the CN Tower, could be quickly identified. Thirty percent of the locations were reported in this manner.

Residents were asked about travel by household members on the previous day. Information was collected six days a week for weekday travel. All trips by household members, older than 5 years, were recorded for travel over the previous 24 hour period (0400hr to 0400hr on the day of the interview). For the walk and bicycle modes of travel only trips between the respondents' home and place of work (or school) were recorded.

Discretion was used on the part of the interviewer to decide when stopovers on trips constituted separate trips. For example, stopping for coffee on the way to work would not be considered a separate trip whereas stopping for a sit-down breakfast would create two trips. For those who travelled repeatedly during the day as part of their job only the first and last work trips were recorded. This category included taxi drivers, bus drivers and the police.

The data collected in the survey can be grouped into three areas, household-related, person-related, and trip-related. Each household, person and trip was given an unique number so that it could be uniquely identified within the database.

The household data include the household location, type of dwelling, the number of persons normally living there, and the number of motor vehicles available at the household for personal use. Person data include the age and sex of the residents, whether each member has a driver's licence, the employment status and the student status of each member. Finally, trip data include the person who made the trip, trip start time, mode and purpose according to eight categories:

- work (first or subsequent)
- school (first or subsequent)
- market/shop
- personal business
- entertainment/social/recreational
- facilitate passenger (pick up or drop off)
- other
- home

Nine modes are identified: walk, auto driver, auto passenger, taxi, bicycle, motorcycle, transit, school bus and other. Additional transit trip information is also recorded. This includes the access mode used to reach the transit stop, the egress mode from the transit vehicle, the location of these transfers and the sequence of transit links in the journey by route number or name and transit property. All trips of which any part is by transit are identified as transit trips to facilitate the examination of the access and egress modes.

An expansion factor was developed to expand the sample to represent the total GTA population. The 1986 Census was used as a base to estimate the total population and total number of dwelling units per census tract. The census tracts were then aggregated to a 268 zone system. Expansion factors were defined for each of the 268 zones as the ratio of Census to TTS dwelling units. Some of the zones were combined prior to the development of the expansion factor in an attempt to ensure that at least 2500 households would be in each aggregation district and thus ensure reasonable statistical reliability. The dwelling unit expansion factor was then used to expand the person records and sample trip records. [MTO, 1988b]

Even though geocoding allows the data to be aggregated to any scale, two zonal systems are also available within the database. One zone system is the 1979 TARMS system. This zonal system provides a relatively fine mesh of 1182 zones across the GTA. These zones were developed for the Toronto Area Regional Model Study (TARMS) which was a Ministry of Transportation traffic forecasting model for the GTA from the early 1970's. The size of the zones are approximately inversely proportional to the population in the zone even though this is not explicitly their basis. A second zone system is the 46 zone municipal system. This system is composed of the 30 GTA municipalities outside of Metropolitan Toronto and the 16 major planning districts within Metro.

The two zone systems are consistent with each other by municipality and planning district throughout the GTA except for the Cities of Toronto, York, North York and the Borough of East York within Metro Toronto. The downtown area of the City of Toronto which contains the Central Business District for the region, the central retail area and government centres are all contained within Planning District 1. This represents a quarter of the area within the City of Toronto.

The data were validated in late 1987 and were found to be generally acceptable. The only major difficulty was an under-estimation of off-peak trips by some 36%. [MTO, 1988a] The peak period trips, particularly in the morning, seemed to correlate well with data from other area studies. The demographics of the population also closely resemble the results from the 1986 Census. Overall, the TTS data set is workable and can be used with a reasonable degree of certainty to represent the GTA, especially with respect to peak period analysis.

Translations of the TTS data were generated as required by the researchers directly from the database using EMPRESS/32 Version 2.4, the database management system used to store and manipulate the TTS database. Most of the subsequent analysis of the data, including the production of most of the tables and figures in this report, was performed using SAS Release 6.03 on a 386 AT personal computer.

CHAPTER 4

TORONTO'S HISTORICAL PATTERN OF DEVELOPMENT

4.1 The Historical Development of the Metropolitan Area

The patterns of settlement and movement of people in any urban area are not simply based on local geography. They are a function of history, political organization and transportation infrastructure. Thus, as a context for understanding the spatial analysis of GTA community patterns presented in the next chapter, one needs to examine the evolution of these factors within the Greater Toronto Area.

Toronto is located on the northwest shore of Lake Ontario, on rolling plains bisected by several large river valleys. The largest of these valleys are formed by the Don and Humber Rivers. The sprawling city now forms the largest urban area within Canada. Approximately 4 million people live in the five Regional Municipalities of York, Durham, Peel, Halton and Hamilton-Wentworth and the Municipality of Metropolitan Toronto which together form the Greater Toronto Area.

Toronto was settled in the 1790's by the British after earlier temporary French and Indian communities. The settlement was located behind a sandy peninsula (the modern Toronto Islands) that formed a protected harbour at the mouth of the Don River. Just to the west was the Humber River which formed an important trade route to the existing European communities on Georgian Bay and to the rich resources of the lands to the northwest.

The settlement was laid out in a fixed grid of concession streets at a mile and a quarter intervals (2 km) which made no attempt to follow the natural terrain. The original east-west concessions were Lot (Queen), Bloor, St. Clair and Eglinton and the north-south concessions were Yonge, Bathurst, Dufferin, Keele. These streets eventually formed the basis of the modern arterial road network. In 1796 Lord Simcoe, the Governor of Upper

Canada, laid out the first long distance street in the area. Yonge St. was built north to Holland Landing, a distance of 41 km, as primarily a military road but also as a trade route. [Kerr, 1965] Later, in 1800, Dundas St. was built west from the city to the village of Dundas, north of Hamilton. By 1801 Kingston Rd. had been built to the east, but remained a lightly used route for many years. These roads set the initial travel corridors for the city and two hundred years later their effect can still be seen.

The community flourished over the years in a compact form south of Bloor St. between the future High Park area and the Don River. By 1834 the city had a population of 10,000 people. [N.D. Lea, 1966]

In 1878 the next major event was the transformation of the city with the arrival of the railways. The railways fanned out from the protected harbour, further concentrating population and employment along the corridors radiating from the centre of the city. Four spines were evident. One moved north along Yonge St., the second along Bloor St. to Etobicoke Township, west of the Humber River, the third was to the northwest to the Village of Weston on the Grand Trunk's Railway's Guelph line and the final arm was to the southwest along the lakeshore to the communities of Mimico and Long Branch. The bridging of the Don Valley by the Prince Edward Viaduct in 1918 finally encouraged more growth to the east and thus created a fifth arm into Scarborough Township.

The city was still relatively compact and well established in the 1920's when the streetcar age was at its peak and was encouraging extensive activity within these spines. Efficient public transportation allowed workers to move increasingly further from jobs in the city. The core density of the city was approximately 20,000 people per square mile (7700 people per km^2). [N.D. Lea, 1966] Today this value is close to 7000 person per km^2, while it is generally 3500 persons per km^2 in the suburbs of Metropolitan Toronto. These values are some of the highest in North America.

Streetcars, which had been introduced to Toronto in 1891 by the Toronto Railway Company, were rationalized in 1921 to form the Toronto Transportation Commission which would serve the City of Toronto. By the late 1940's the growth of automobile ownership and the resulting increase in mobility allowed people to move away from the public transportation spines and the city's shape became more balanced as the space between the spines was developed. One of the major efforts in this regard was the Don Mills community in the northeast which was developed in the 1950's and 1960's.

Historically the vast majority of incremental growth was in the west. The Humber River was much less of an impediment to growth than the Don River. Toronto was also much more closely tied to the growing centres of Hamilton, Kitchener and London southwest of the city. The pattern of growth of Metropolitan Toronto between 1793 and 1961 is illustrated in Figure 4.1.

4.2 Toronto's Transportation Infrastructure

The growth of automobile usage had prompted the need for a system of highways. The Queen Elizabeth Way (the QEW), the first freeway in Canada, opened between Toronto and Hamilton in 1940. [N.D. Lea, 1966] In the early 1950's Highway 401 was built north of the city to bypass Toronto. The urban area promptly grew to surround the highway which was then expanded to a twelve lane complex. This highway is the main artery of the highway system in the metropolitan area today. By the late 1960's, the Don Valley Parkway (DVP) was completed into the downtown along with the Gardiner Expressway, an elevated expressway connecting the QEW with the downtown and the Don Valley Parkway. Much of the rest of the planned expressway system into the central area was then cancelled due to several political factors.

Along with the growth in the road network the Toronto Transportation Commission was replaced in 1954 by the Toronto Transit Commission which served a much larger area. In 1954 the first subway in Toronto was opened. The Yonge Subway extended from Union Station at the south end of the CBD to Eglinton Ave. in the northern suburbs. It replaced the existing streetcar lines on the same route. Subsequent extensions of the system between 1963 and 1980 saw the completion of the University Subway, the Bloor-Danforth Subway from Kipling to Kennedy and the Spadina Subway. The major effect of this construction

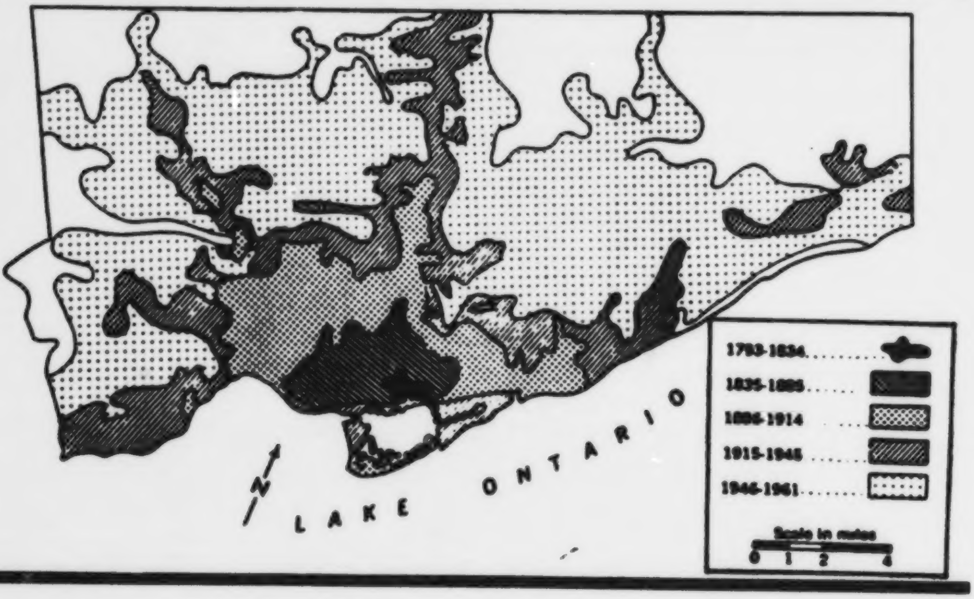


Figure 4.1 Growth of Metropolitan Toronto (1793-1961) [Kerr, 1965]

was the reinforcing of the earlier streetcar lines and the promotion of major commercial and residential growth in the subway corridors.

The final major infrastructure improvement involved the creation of GO (Government of Ontario) Transit in 1967 to serve the regional commuter market with a high quality heavy rail service which would replace the existing, but limited, CN and CP commuter service. GO Transit serves an area up to 90 km from downtown Toronto. [GO Transit, 1986] Six rail corridors are in place. The original Lakeshore line runs from Hamilton to Pickering. Full service is only provided between Oakville and Pickering. In 1988 service was extended east to Ajax and Whitby. In addition to the Lakeshore line subsequent rail corridors were developed by GO Transit to Georgetown in 1974, retracing the old Grand Trunk service to the northwest, in 1978 to Richmond Hill, in 1981 to Milton and to Stouffville and Bradford in 1982. The TTS data indicates that 23,000 daily home to work trips into downtown are made on the rail system. A schematic of the GO rail system is presented in Figure 4.2. GO Transit also operates numerous bus services. These services link Hamilton and downtown Toronto, Pickering and Oshawa, feed the Finch subway station on the Yonge subway from York Region and connect the Yorkdale subway on the Spadina line from the west and northwest in Brampton, Mississauga, Halton and Wellington County.

Today the area is served by many transportation systems. As mentioned earlier, Hwy.401 is the major expressway across the top of the Metropolitan area crossing from southern Durham to Halton. The QEW provides access between Niagara, via Hamilton, with the City of Toronto, via the Gardiner Expressway. Thus the QEW provides direct highway access to the downtown for residents in Mississauga, Oakville and Burlington. Hwy.427 links the 401 and QEW in Etobicoke. This is the only direct freeway link from northwest of Planning District 1. The Don Valley Parkway provides highway access from the northeast and has been extended north of the 401, as Hwy.404, into York Region. In the west, Hwy. 400 provides similar access as far south as Hwy.401. The final major highway link in relation to the downtown area is the Allen Road. This is the start of the Spadina Expressway that was originally designed to go to the downtown. The route is now

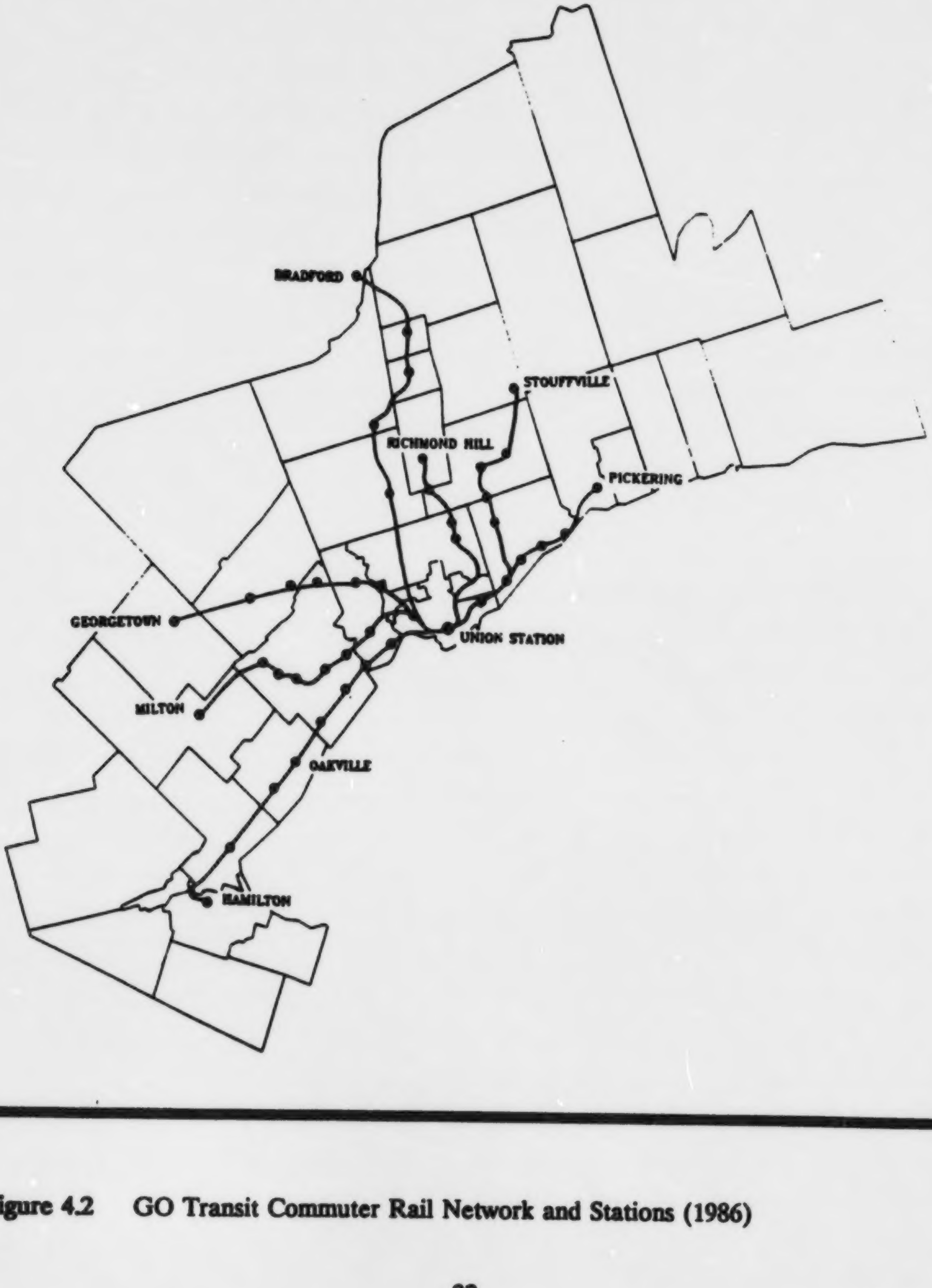


Figure 4.2 GO Transit Commuter Rail Network and Stations (1986)

stub-ended at Eglinton Ave. in the northwest, six kilometres from downtown. Superimposed on top of the area is a grid network, spaced at approximately two kilometres intervals, of arterial roads. Generally these roads are four to seven lanes wide (generally wider in the suburbs). There are some missing links in this grid, particularly in the Don Valley corridor. As expected, the highway routes into the downtown core and often the 401 experience acute traffic congestion on a daily basis.

The largest transit operator in the Toronto area is the Toronto Transit Commission (TTC) which operates a relatively fine grid network of high frequency transit routes within Metro. One hundred and thirty seven routes make 195 connections at subway stations and the system carries about 1.5 million daily riders. [TTC, 1989] A map illustrating the location of the TTC's subway and RT system is presented in Figure 4.3. Outside of Metro various local transit properties, which are much smaller than the TTC, provide limited service. The largest of these local properties is Mississauga Transit which began in 1971 and serves Mississauga in southern Peel Region. [Crowley, 1972] Many of its routes feed into the Islington subway station on the Bloor subway in Etobicoke. Most of the other larger, urban municipalities also operate local transit systems. Overall their are sixteen transit properties in the Greater Toronto Area.

As has already been mentioned, the GTA is politically divided into six regions, each with a two-tier local government structure, which results in 36 municipalities. Figure 4.4 presents the 1986 population of each municipality. The traditional urban centre of the region is Metropolitan Toronto which was formed in 1954 and contains the City of Toronto, including the downtown. Other traditional "downtown" areas can also be found in the Cities of Hamilton and Oshawa. Most of the other areas are either suburban or rural. Industrial districts are found throughout the area.

The downtown area is the traditional centre of Toronto, which has grown to become the ninth largest Metropolitan area in North America. [Metro Toronto Planning Dept., 1986] The city is the nation's financial centre as well as a centre for local and regional government and the provincial capital. Major educational facilities are also found in the

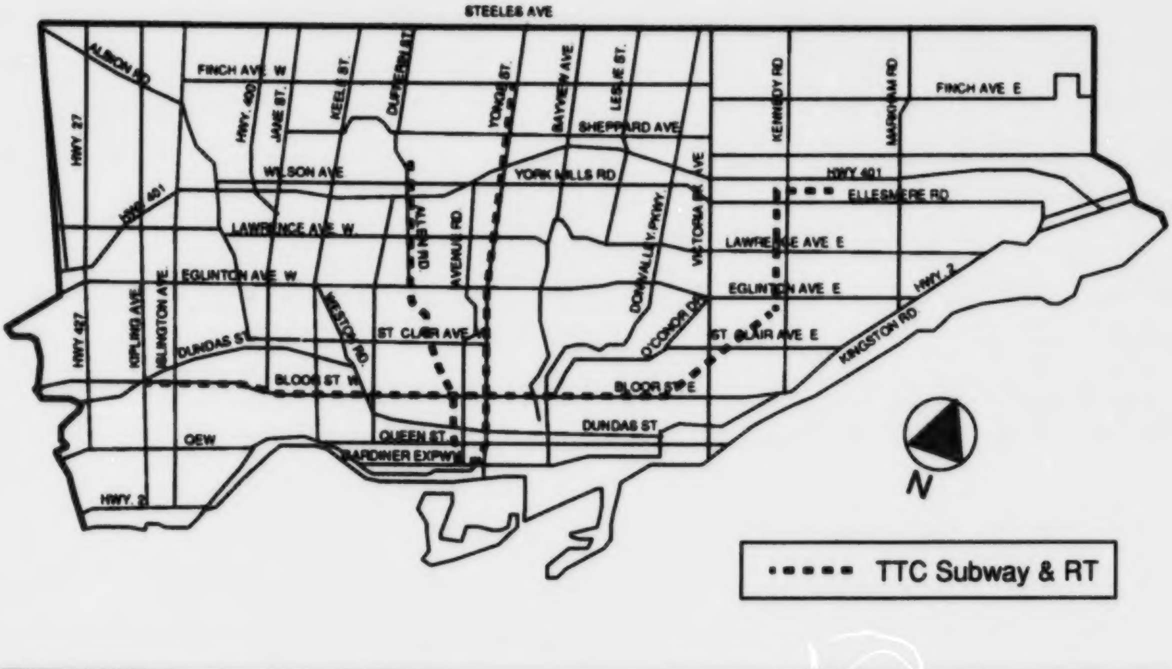


Figure 4.3 TTC Subway and RT System

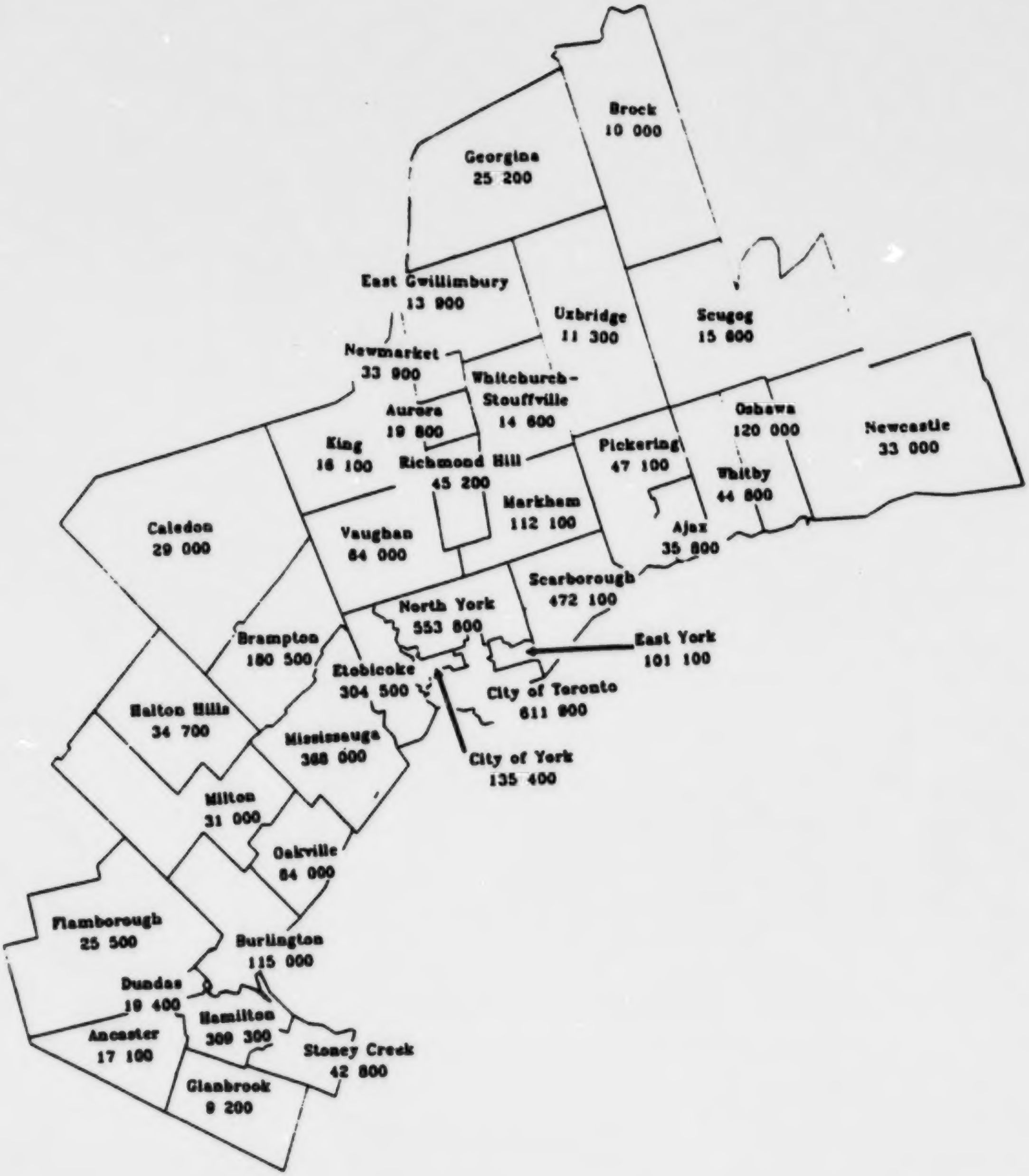


Figure 4.4 Population by Municipality in the Greater Toronto Area (based on TTC data)

city centre as well as a large concentrations of hospitals. The traditional retail centre is still found in the downtown although suburban shopping has also increased. The central area also contains a significant number of tourist attractions including stadia, museums, art galleries and special parks.

The downtown area contained 406,000 jobs in 1987, which had increased from 347,000 in 1983. [Municipality of Metro Toronto, 1988] Sixty percent of these jobs were in the office sector, 7% in manufacturing and warehousing, 12% institutional and 7% retail. The recent growth of the central area can best be described using the increase in central area office space. Since the first tower of the Toronto Dominion Centre opened in 1967, massive development has occurred. From 1971 to 1988 downtown office space grew from 1,888,000 m^2 to 5,657,000 m^2, or by 200%. As of 1988 2.6 million square metres in additional office space has been proposed for future development. [Metro Toronto Planning Dept., 1986, 1988]

CHAPTER 5

ANALYSIS OF WORK TRAVEL TO THE TORONTO CENTRAL AREA (PD1)

5.1 Introduction

The focus of this study is travel to the central area of the City of Toronto, which, for the purpose of this study, is defined as Planning District 1 (PD1), shown in Figure 5.1. Home based work trips into PD1 are used for the analysis as they represented a stable, repeatable and comparable basis for the spatial analysis. People who made secondary trips on their way to work are disregarded, primarily because they generate a relatively small percentage of the PD1-destined, home-to-work trips. The morning commute, which the home-to-work trips generally represent, is typically better behaved temporally than the evening commute, both because significantly fewer trips are made for other purposes in the morning and there is less of a tendency for trip linking. Five modes are considered in this report: auto driver, auto passenger, transit, walk and cycle. Each mode is defined in more detail later in this chapter.

Five major topics are investigated in some detail in this chapter: the temporal distribution of start times for home-to-work trips to PD1 (leading to the definition of the morning peak period); the relative importance of PD1 to the GTA as a centre of employment and, hence, as the destination of work trips within the GTA; the spatial variation in PD1 dependency of the resident labour force across the GTA; the variation in PD1-oriented work trip rates by age, sex and origin region; and the modal distribution of PD1-oriented work trips. This last topic is investigated in considerable spatial and modal detail. Each of these topics is discussed in one of the following sections.

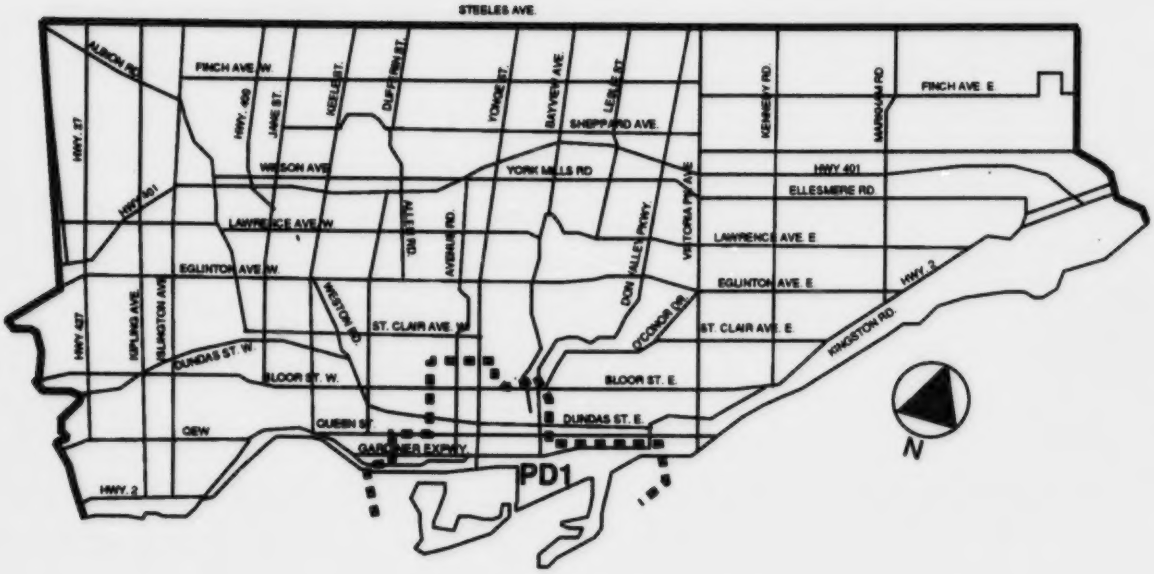


Figure 5.1 Location of Planning District 1 within Metropolitan Toronto

5.2 Temporal Trip Distribution

Figure 5.2 presents the temporal distribution of start times for home-to-work, PD1-destined trips. Examination of this distribution indicates that the morning peak period, defined in terms of trip start time, is best described by the three-hour period from 0600hr to 0859hr, inclusive. This relatively broad peak period definition is necessary, given the long commuting times experienced by workers living in the outer areas of the GTA.

Considering the trip start time distributions for each origin regional municipality, it is found that the Regions of York, Peel and Halton have similar shaped distributions. The peak half hour occurs between 0645hr and 0715hr (Figures 5.3 and 5.4). The shift to the earlier part of the peak period reflects the travel time required to reach the downtown from these more distant communities. The Region of Durham shows an earlier peak between 0615hr and 0645hr (Figure 5.5). Thus, a potential travel impediment between Durham and the central area appears to be forcing an earlier travel start time than for commuters from the west and north. The peak shifts later as one moves into Metro Toronto, until finally within PD1 the start times are concentrated at the later portions of the peak period definition (Figures 5.6 and 5.7).

An examination of the temporal differences between modes indicates that the auto driver start time distribution is broader than the distribution for the transit mode. This likely reflects auto drivers' ability to use their increased travel time flexibility to leave home outside the limits imposed by transit schedules (Figures 5.8 and 5.9).

5.3 The Importance of Planning District 1 to the GTA

In most North American cities the downtown core traditionally contained the majority of the urban area's retail and commercial employment. Decentralization has occurred as the population has suburbanized. This has led to a movement of large retail establishments and commercial businesses away from the city. Today large scale office complexes can be found in many suburban areas that rival the traditional downtown complexes. Thus, central areas have lost much of their monopoly on commercial activity within many cities.

Temporal Distribution of Trip Start
Times to PD1 within the GTA
home-to-work trips, all modes

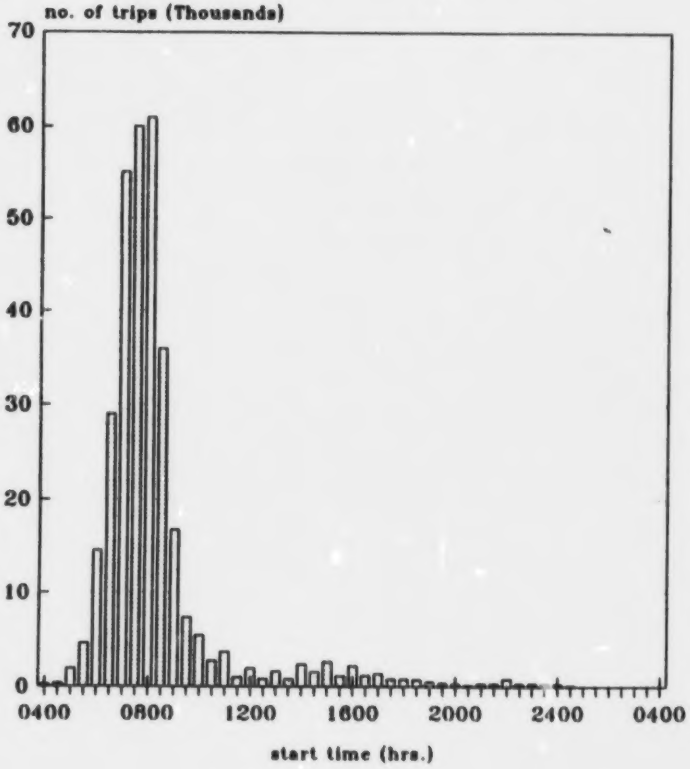


Figure 5.2

Temporal Distribution of Trip Start
Times to PD1 from York Region
home-to-work trips, all modes

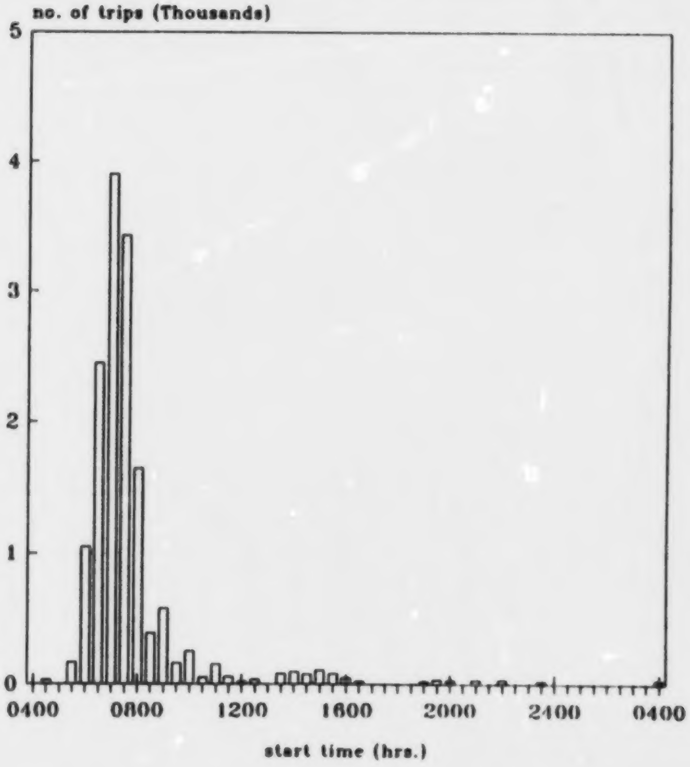


Figure 5.3

Temporal Distribution of Trip Start Times to PD1 from Peel & Halton Regions home-to-work trips, all modes

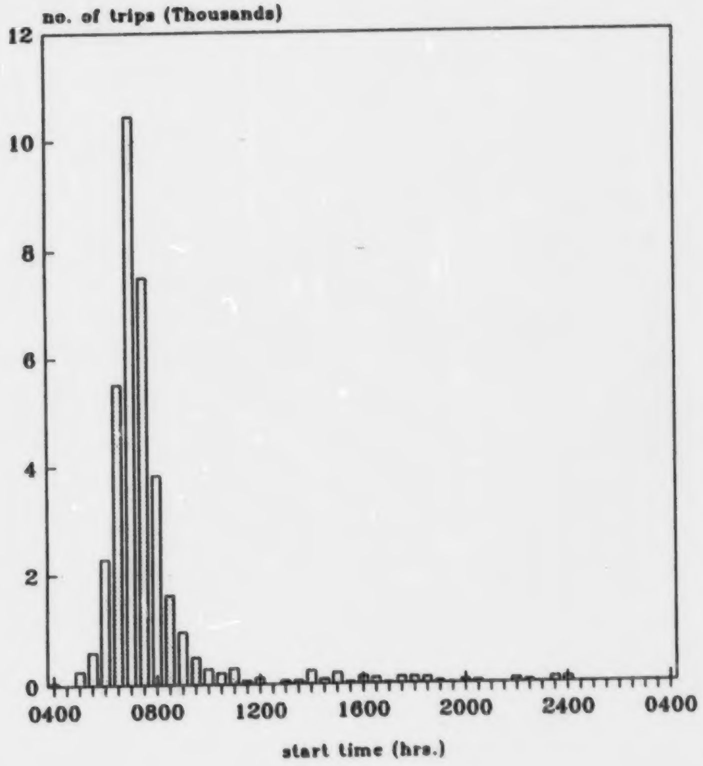


Figure 5.4

Temporal Distribution of Trip Start Times to PD1 from Durham Region home-to-work trips, all modes

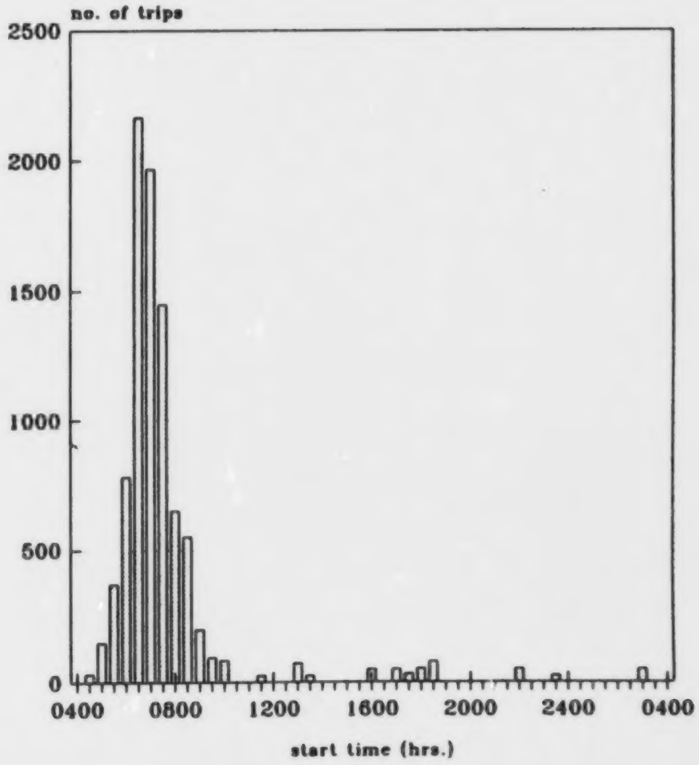


Figure 5.5

Temporal Distribution of Trip Start
Times to PD1 from Metro Toronto
(excluding PD1)
home-to-work trips, all modes

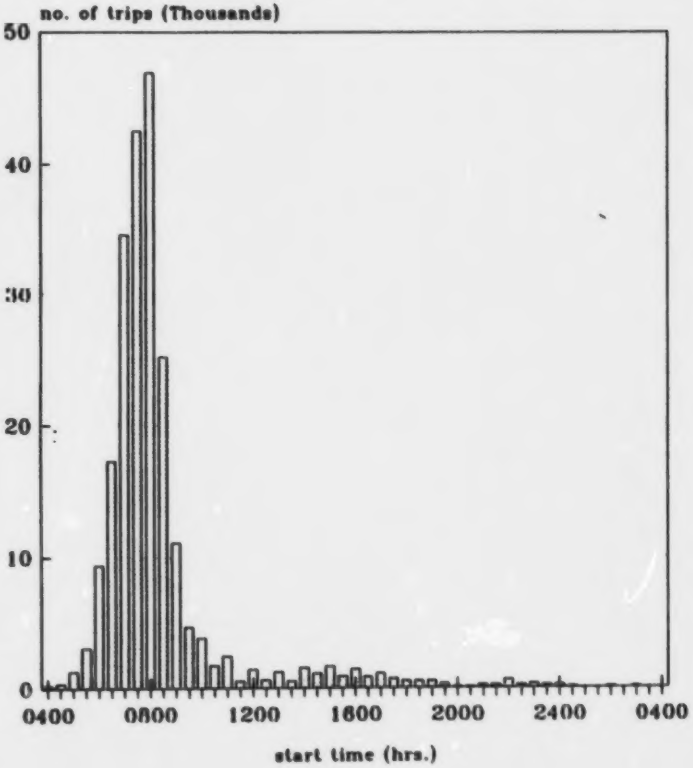


Figure 5.6

Temporal Distribution of Trip Start
Times to PD1 from within PD1
home-to-work trips, all modes

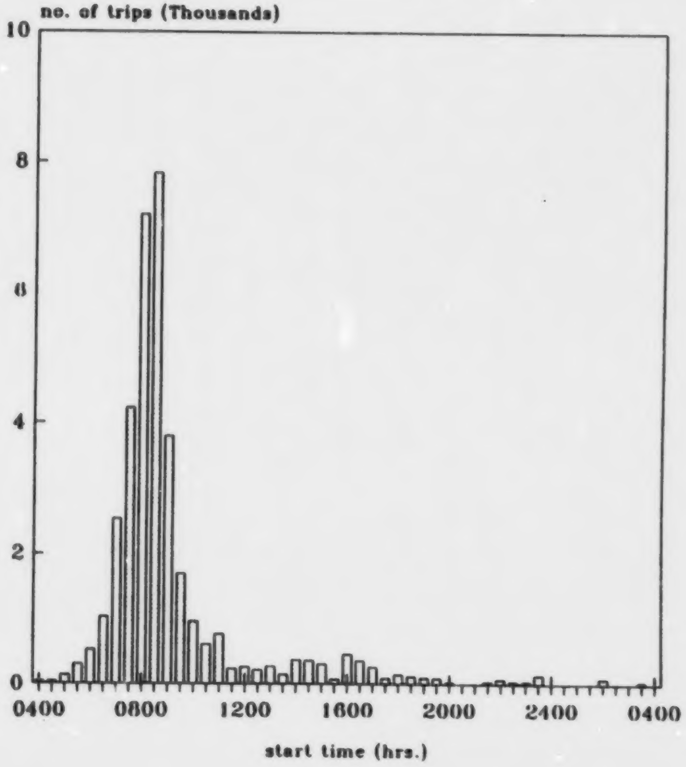


Figure 5.7

Temporal Distribution of Trip Start
Times to PD1 within the GTA
home-to-work trips, as an auto driver

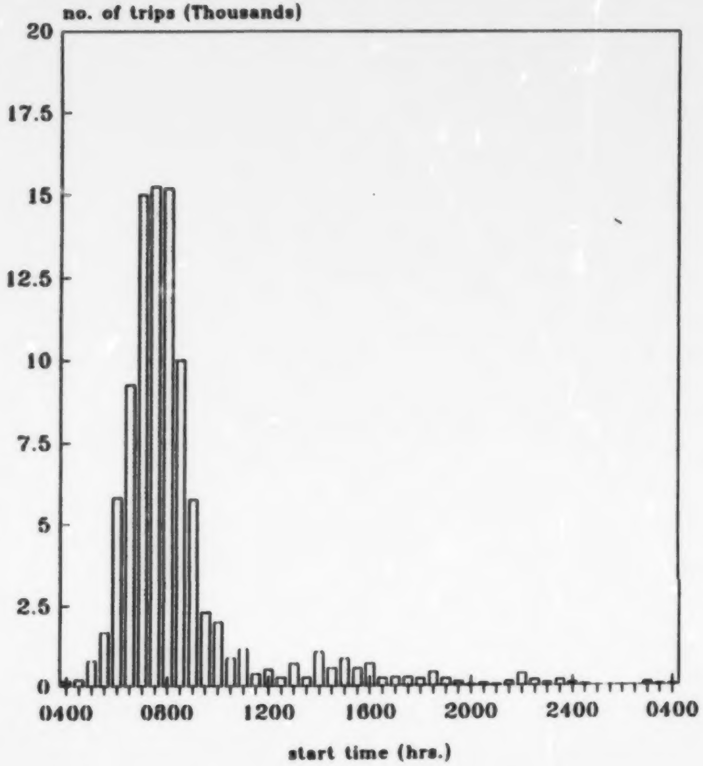


Figure 5.8

Temporal Distribution of Trip Start
Times to PD1 within the GTA
home-to-work trips, by transit

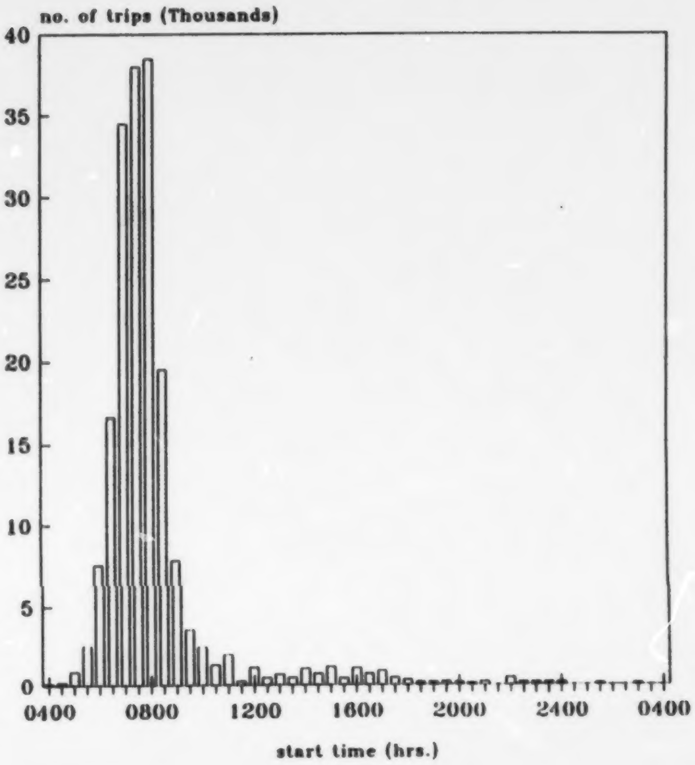


Figure 5.9

Unlike many other North American cities, Toronto's central area has seen tremendous growth, despite the concurrent growth of suburban centres. Evidence of this vitality can be seen in the 321,000 home-to-work trips being reported to PD1 on an average work day in 1986. Planning District 1 covers an area, excluding the harbour, of 20 km^2. Within the 8700 km^2 Greater Toronto Area 20% of the daily home-to-work trips are made to the downtown core. This figure rises to 30% within Metro Toronto and increases to one-half for the trips made by the 600,000 residents of the City of Toronto. This illustrates the overwhelming importance of PD1 to the GTA.

The 1964 MTARTS (Metropolitan Toronto and Region Transportation Study) suggested than one-third of the region's employment was in the "Toronto Core Area" (PD1). [Province of Ontario, 1966] Thus, a decreasing percentage of GTA home-to-work trips are being made to Toronto's central area as more employment becomes available in the suburbs. The absolute level of PD1 employment continues to rise, however, and thus the central area remains a fundamental concern for transportation planners.

Examining the four regions surrounding Metro Toronto, there is a consistency in the proportion of home-to-work trips destined to PD1 (see Figure 5.10). Although each region contains industrial/commercial centres or even a separate "downtown", approximately 10% of all home-to-work trips are still made from each of these regions to PD1. This value varies from a low of 8% from Durham Region to the east, to a high of 12% in York Region to the north. The similarity in PD1 orientation is not evenly distributed within each of the regions, however. Within each municipality there are communities that are much more dependent than others. Peel Region is clearly the dominant source for central area workers outside of Metropolitan Toronto, with forty-three percent of all the non-Metro home-to-work trips originating in this region.

The Region of Hamilton-Wentworth has an extremely low PD1 home-to-work trip interaction of only 1% or 1900 trips. This is only 0.6% of all trips destined to PD1. This low interaction occurs for several reasons. Hamilton-Wentworth has a large and well established local job pool based on the steel industry and related heavy manufacturing.

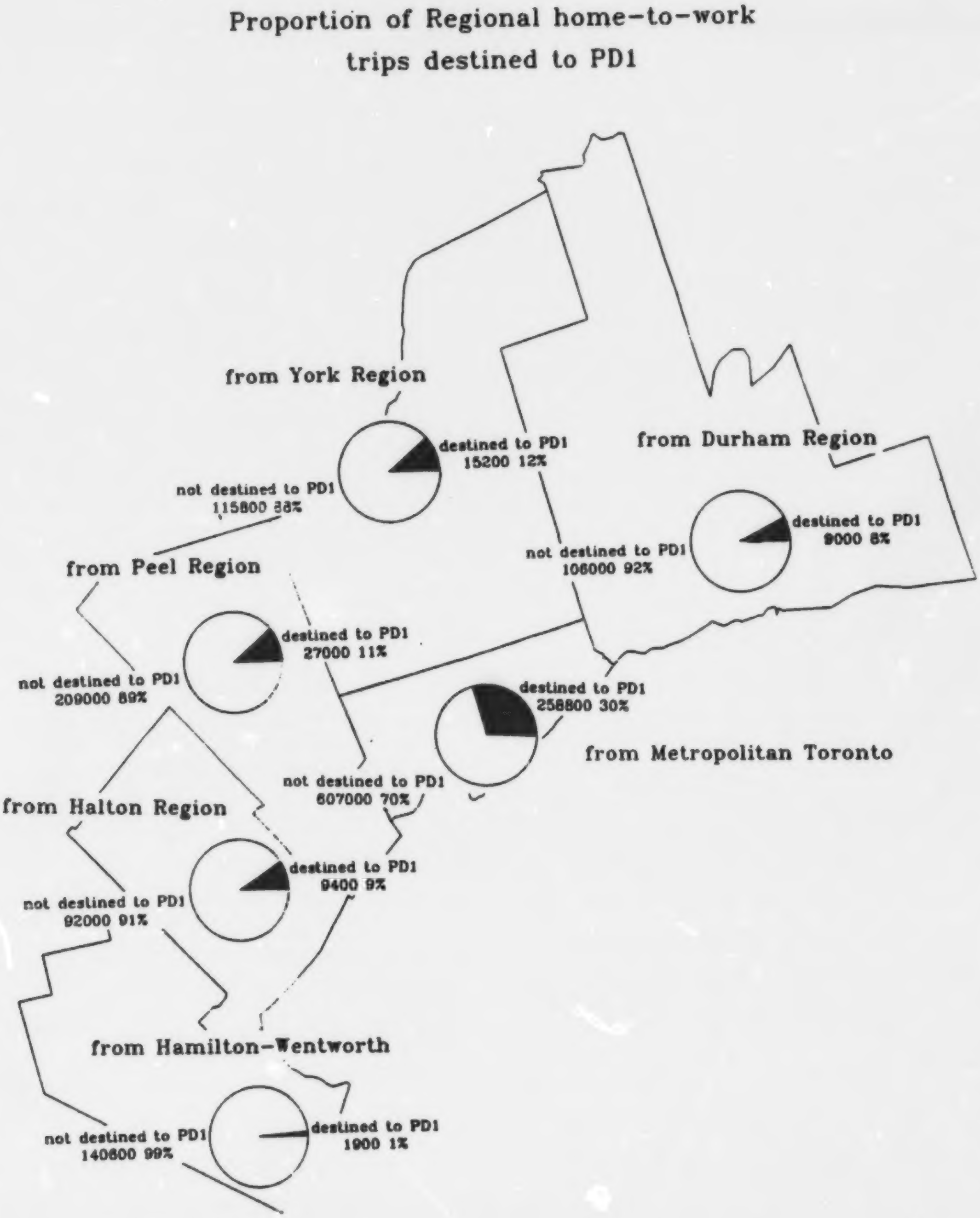

Proportion of Regional home-to-work
trips destined to PD1
from York Region
destined to PD1
15200 12%
not destined to PD1
115800 88%
from Durham Region
destined to PD1
9000 8%
not destined to PD1
106000 92%
from Peel Region
destined to PD1
27000 11%
not destined to PD1
209000 89%
destined to PD1
258800 30%
from Metropolitan Toronto
not destined to PD1
607000 70%
from Halton Region
destined to PD1
9400 9%
not destined to PD1
92000 91%
from Hamilton-Wentworth
not destined to PD1
140600 99%
destined to PD1
1900 1%

Figure 5.10

This region also has a well defined and historic "downtown" commercial and office district and a distinct, older urban core, unlike the other regions. Anecdotal evidence and some of the later evidence within this report indicates that in the future this region will likely become increasingly more dependent on the central area of Toronto. This growth in commuter traffic or growing dependency cannot been addressed in this analysis, however, which can only provide a snapshot of the present situation.

Other points become clear upon examining the region of residence of the workers travelling to PD1 (Figure 5.11). The numerical dominance of those who live in Metro is apparent. Metro Toronto contains 52% of the GTA population [Ontario Ministry of Transportation, 1988c] but 81% of the central area commuters. Within the City of Toronto local dominance is also evident as 37% of the PD1 commuters are residents of the City. This indicates a relatively strong match within the City between downtown employment and workers.

The remaining regional municipalities contain 19% of the home-to-work origins. Peel, again, contains the largest share at 8% (27,000), followed by York at 5% (15,000) and Durham and Halton at 3% (3000). The past growth of the regions has dramatically increased the regional share of central area work trips. These proportions are likely increasing rapidly due to the high rates of population growth in the regions, but this rate of growth cannot be determined from the TTS data alone.

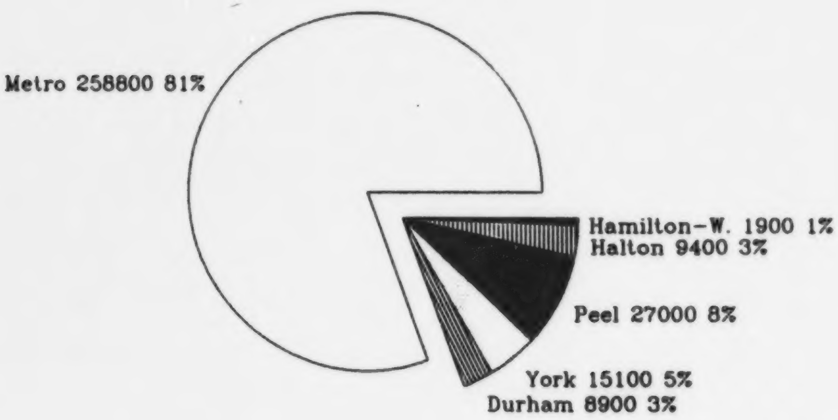
5.4 The Spatial Variation of PD1 Dependency

As discussed earlier, trip attractions to the city centre generally should decrease with increasing distance and time of travel from the city centre. This is because workers should attempt to minimize the cost of work travel. This would still be subject to the unique urban spatial structure of the city, which is a result of specific geography and historical patterns of growth.

Residents in close proximity to the central area are, in fact, filling many of the jobs within PD1. Overall 63% of home-to-work trips originating from Planning District 1 are destined within the district, representing 11% of the central area employment or 35,000

Proportion of Trips generated by each Region

home-to-work trips, destined to PD1



Identifying Metro Toronto Municipalities

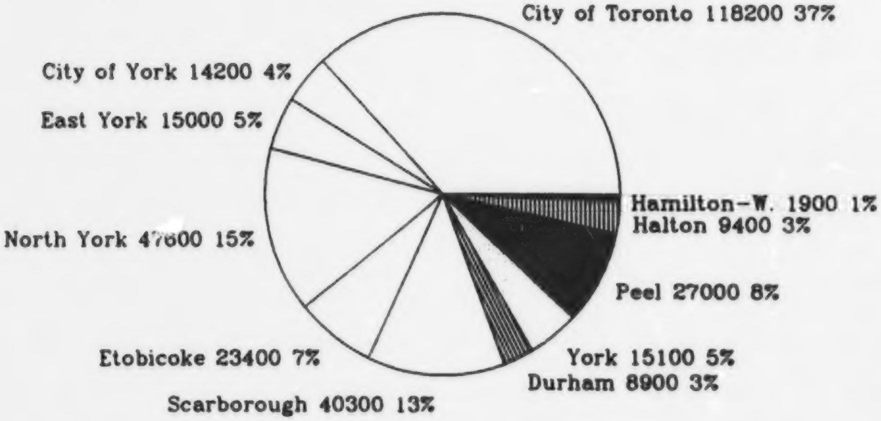


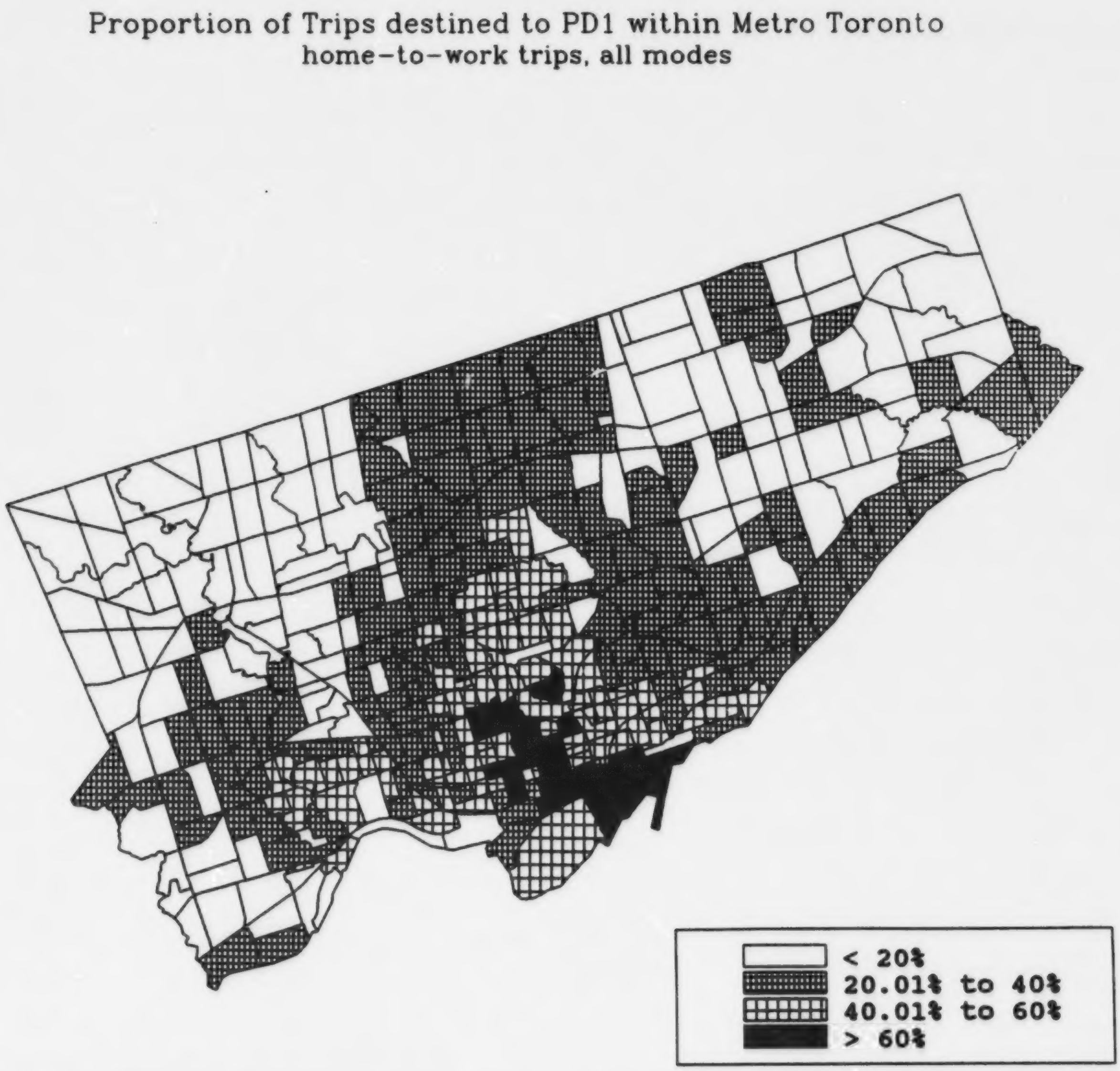
Figure 5.11

trips. Therefore there is a relatively large city centre population in Toronto and they are generally finding employment locally.

The theoretical concept that workers concentrate near jobs need not occur in large metropolitan cities. The mismatch may be due to urban decay and other "big city" problems which can deter workers from living locally and leave the downtown housing to fall into disrepair, lose value and then be inhabited by those who can afford nothing else. Thus, having a well matched central city housing stock cannot be taken for granted.

The City of Toronto's 1976 Official Plan states that one of the City's policies is to encourage the development of central area housing. Between 1976 and 1986 the population of the central area increased by 15% and the number of dwelling units by 30%. [Nowlan, 1989] There is also an increasing proportion of central city residents who are finding local employment. A 1982 City of Toronto survey of some downtown workers discovered 47% of them were working within the central area. This survey was based on a small, randomly selected central area residential sample of 2200 working-age people with a 44% response rate. [City of Toronto, 1982] An earlier study in 1973 indicated that 42% of downtown residents worked locally. [Klein, 1973] The growth in the downtown core in both jobs and residences is intensifying local job opportunities for current residents as well as encouraging more downtown workers to reside there. Thus, there has been an apparent improvement in the match of residents to employment in the central area. Spatially within the central area, the proportion of workers is constant across the TARMS zones. PD1 workers do not seem to be concentrated in one area relative to those workers who find employment elsewhere in the GTA.

Surrounding Planning District 1 is a zone from which fewer home-to-work trips are being made to the district. This can be seen in Figure 5.12. In this area the percentage of trips destined to PD1 drops to the 40 to 60% range, with most zones at approximately 45%. Unlike many of the theoretical concepts of worker dispersion, this secondary band does not form a ring but instead forms an inverted "T" shape. The three arms extend north, east and west from PD1. The northern band extends on both sides of Yonge St. between Bathurst St. and the Don Valley as far north as York Mills Rd. The eastern band



Proportion of Trips destined to PD1 within Metro Toronto
home-to-work trips, all modes

Figure 5.12

is between the Danforth and the Lake while the western band extends along Bloor St., declines between Dundas St. West and Parkside Dr., then increases again in the High Park, Swansea and the Kingsway area of Etobicoke.

This zone generally follows the two major subway lines within Toronto, north along Yonge Street and east-west along Bloor-Danforth. It would seem that 35 years of subway service and the previous streetcar routes in Toronto have reinforced the PD1 orientation of certain areas. The arms of PD1 dominance do not exclusively follow the subway routes though, as is seen later. These bands also tend to be confined by the political borders of the City of Toronto, even though these borders generally follow no geographic features and are arbitrarily political and historical in their definition.

Beyond this second area is a third, broader zone which generally extends the "T" shaped pattern. Within this zone from 20% to 40% of the home-to-work trips are destined to PD1. This third zone fills in the rest of the City, extending to the west into Etobicoke, the east into Scarborough, while to the north it covers the Willowdale and Don Mills areas of North York. There is a tendency for the northern arm of PD1 dominance to drift to the northeast. This shift is even east of Yonge St. and roughly parallels the Don Valley.

The lower levels of PD1 dominance extend towards the central area from the northwest and, to a lesser degree, from the northeast. These prongs exhibit a much lower PD1 orientation of approximately 15%. These two areas follow the traditional industrial/blue collar "U" of Toronto. [Miller and Cubukgil, 1981]

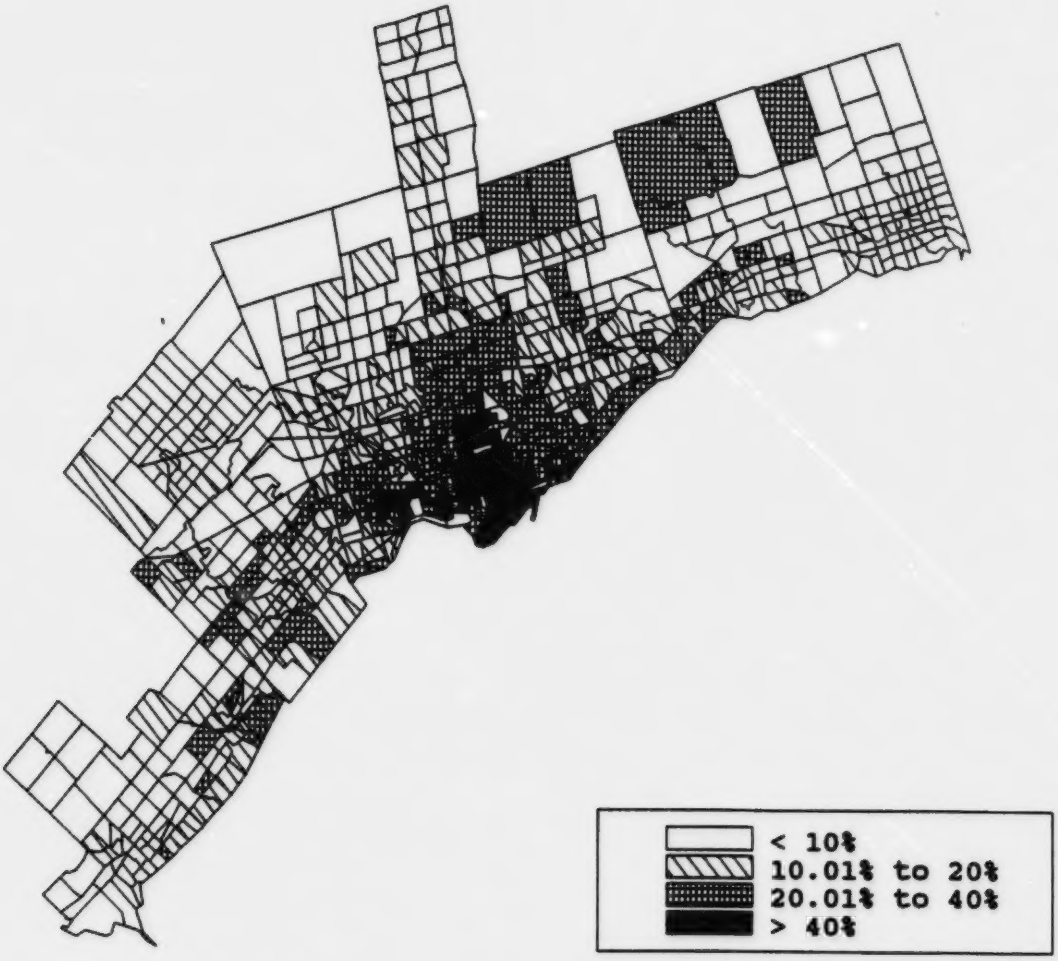
In Scarborough the eastern arm of the "T" pattern continues along the shore of Lake Ontario. This primarily residential area averages a 30% dependence on PD1 for home-to-work trips. In the central and northwestern areas of Scarborough the proportion drops significantly below 20%. Finally in central, northern Scarborough in the Milliken area the proportion rises again to approximately 30%.

The east Milliken area had been recently developed at the time of the survey. To the west of Milliken is a residential area which was developed a few years earlier. This eastern area has a significantly lower PD1 orientation even though the areas are almost identical in urban form. The difference could potentially result from variations in the development dates of the two communities. In the mid 1980's when more of a demand for downtown workers was evident, the second area was being developed and likely captured more downtown workers who were looking for homes. The earlier area was developed in the late 1970's before this surge.

The "Inner GTA" has been defined for use in the regional spatial analysis. This area consists of municipalities which have a high level of work trip interaction with PD1. The Inner GTA is composed of the six municipalities in Metropolitan Toronto as well as Pickering, Ajax, Whitby, Oshawa, Markham, Vaughan, Richmond Hill, Aurora, Newmarket, Mississauga, Brampton, Oakville and Burlington. Interactions between each of these municipalities and PD1 are discussed in the following paragraphs.

East of Metropolitan Toronto in Durham Region most of the spatial variation occurs within the four southwestern municipalities of Pickering, Ajax, Whitby and Oshawa (Figure 5.13). Only 10% of the Region's trips originate in the large area outside of these municipalities. The four municipalities can be subdivided into two groups. The eastern pair, Whitby and Oshawa, have a dependency generally below 10%. The relatively few tripmakers (2600) are concentrated on the periphery of the two urban areas. This low interaction level can be expected due to the large and well established local employment base. These communities are also 45 km from downtown and were without a direct rapid transit connection in 1986.

The western pair of municipalities, Pickering and Ajax, show a substantially different interaction with PD1 and produce 5300 trips. A band of zones having a 20 to 40% home-to-work trip dependence continues from the adjacent Scarborough lakeshore band and rings the western, northern and eastern urban areas of the two towns. The inner suburbs have between ten and twenty percent of their workers travelling to the central area. These towns



Proportion of Trips destined to PD1 within the Inner GTA
home-to-work trips, all modes

Figure 5.13

are primarily suburban residential communities, but again, as in northern Scarborough, there is evidence of recently constructed fringe housing (mid 1980's) generating a higher proportion of PD1 commuters.

The effect of distance from the central city and thus gravity model concepts are also apparent. The two eastern municipalities are much less PD1 dominated that the western pair. This effect is discussed again in the modal analysis of Durham Region.

York Region, to the north, produced 5% of all PD1 workers or 15,000 trips. The vast majority of these trips come from the five suburbanized southern and central municipalities of Markham, Vaughan, Richmond Hill, Aurora and Newmarket. The various communities and urban areas show notably differing spatial patterns. There is a general background proportion of 12% throughout the urban areas of the Region.

In the Milliken area of Markham there is again a split between subdivisions developed in the mid 1980's and late 1970's. Up to 22% of the home-to-work trips from the eastern area are destined to PD1, which is a continuation of the situation in Scarborough, while the earlier subdivisions to the west show lower values which are again analogous to those to the south in Scarborough.

The proportion of trips from Thornhill are high, 20%, but not to the extent seen in the Willowdale and Don Mills areas to the south of Steeles Ave. The two areas show a distinct difference across this interregional border. Elsewhere in the Region the north Yonge corridor produces significant numbers of commuters, including Aurora and Newmarket which are 40 km from PD1.

Generally, the eastern half of York Region is more PD1-dependent than the western half. The Woodbridge area of Vaughan, to the west, has almost no PD1 interaction (500 trips or 6.3% of the total home-to-work trips). Conversely, the Markham-Unionville area to the east, comparable geographically, produces 2200 trips or 13% of the local home-to-work trips. The shift to the east is a continuation of the Don Valley corridor effect seen within Metro Toronto.

In Etobicoke, to the west of PD1, three distinct zones can be seen. The high concentration along Bloor St. in Toronto continues across the Humber River into this municipality. In the Kingsway area (south of Dundas and along Bloor St. to Mimico Creek) upwards of 50% of the workers are destined to PD1 from this high income, residential area. The second Etobicoke zone is a triangular expansion of the first and covers much of central part of this City (south of Hwy.401 and north of the QEW). The average proportion of home-to-work trips destined to PD1 for this zone is approximately 24%. Finally, the northern and southern areas of Etobicoke are PD1 averse. In the north, Rexdale has a low interaction level of only 10%. Similarly, southern Etobicoke has a low proportion of home-to-work trips destined to PD1. Two exceptions occur in the Long Branch and New Toronto areas, in the extreme southwest, where the value rises to 23% from a low 14% in the surrounding areas.

Peel Region displays patterns analogous to what was observed in Durham Region to the east. In the northern part of the Region, in the City of Brampton and the Town of Caledon, there is little PD1 interaction. Brampton has a large population of approximately 180,000 and is at the same distance from PD1 as Pickering. Nevertheless, only six percent of the home-to-work trips from this municipality are destined to the central city. However this still represents a substantial 4500 trips. There are several hypotheses which might explain this situation. Historically Brampton developed in isolation from Toronto and did not become a commuter town until lately. It also has a large industrial belt to the south and east and many large employers.

Mississauga, to the south, is a much more PD1-oriented suburb. This city generates 22,000 home-to-work trips destined to PD1, which is 15% of all work trips in the municipality. Another ring of higher PD1 generation has developed around Mississauga. It begins as a continuation of the triangular 20% area in neighbouring Etobicoke and then extends across the northern urbanized edge of Mississauga between Eglinton Ave. and

Burnhamthorpe Rd. Approximately one in four of the workers in these zones are destined to PD1. Also to the south are highly PD1-oriented areas in the Lorne Park and Port Credit communities. In these older residential communities approximately 22% of the workers are employed in PD1. Two factors possibly cause this spatial pattern in Mississauga. The southern areas likely contain housing conducive to the PD1 executive and the area is well located with respect to the transportation system. In northern Mississauga the age of the housing is likely again a factor.

Further west is Halton Region, which is a minimum of 30 km from PD1. Most of the trips originate from the lakeside municipalities of Oakville and Burlington. The northern towns of Milton and Halton Hills (Georgetown and Acton) are only 7%, 7% and 4% PD1 dependent respectively. They are all served by commuter rail transit. The service in Milton was only five years old when the survey was performed.

Conversely, Oakville is 16% PD1-dependent. This is largely a commuter community. In many of the zones in central and eastern Oakville the rate is over 25%. A remote and heavily dependent downtown community has developed in this municipality. Finally, in Burlington 7% of the home-to-work trips are destined to PD1 but the municipality is a minimum of 45 km from downtown.

As mentioned earlier Hamilton-Wentworth produces few trips and they are insufficient for a spatial analysis.

In conclusion, PD1 orientation is heaviest among the local residents in Planning District 1 and thus there is a relatively strong and growing resident-worker match downtown. As one moves away from PD1 an inverted "T" shaped spatial distribution is evident where greater than 40% of the home-to-work trips are destined to Planning District 1. This band extends from Islington Ave. in the west, to Victoria Park Ave. in the east and York Mills Rd. in the north. The "T" extends a distance of 10 km from PD1. A band of between twenty and forty percent of home-to-work trips destined to PD1 then envelops much of the urban area from the lakeshore in Scarborough, encircling Pickering and Ajax, covering all of Willowdale and Don Mills as a block, extending across central Etobicoke, the extremities of much of Mississauga and then reappears within central Oakville.

There appears to be a relation between housing construction dates in the extremities and the propensity of a resident to work in Planning District 1. This implies that workers who are willing to commute downtown are buying more of the new housing surrounding areas such as Mississauga than those in the older, central areas of these suburbs. The residents of these older, central areas likely had found local employment when their community was more of a distinct district within the urban area. The growth in central area employment is encouraging more of these downtown workers to search further out in the urban area for (affordable) housing and to reside in the newer areas of the suburban communities.

Areas of low PD1 interaction push into these envelopes, particularly from the northwest. One such area from Brampton pushes as far as the Junction area in the City of Toronto. A similar but less defined zone also extends across much of central Scarborough. Thus the inverted "T" tends to be slightly tilted to the northeast.

Examining the distribution of trip distances[1] for home-to-work trips destined to PD1 (Figure 5.14) and the equivalent distribution for non-PD1 trips (Figure 5.15) a distinct difference can be observed. The Planning District 1 trips are not declining constantly with distance from PD1, as opposed to the non-PD1 trip distribution which describes a fairly smooth aggregate relationship with distance. Trips to PD1 tend to peak at 5 km from work and then decline to a trough at approximately 11 km where the effect of the non-PD1-oriented areas pushing in from the northwest and northeast is evident. The numbers then sharply increase again as the large PD1-oriented area in Willowdale and Don Mills is reached. At 21 km, a distance where most of the population centres in Metro Toronto have been crossed, the lower regional numbers then become evident. Eighty-six percent of the PD1 commuters live less than 21 km from downtown (Figure 5.16). Figure 5.17 indicates

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[1] Measured as a straight line distance.

Distribution of Trip Distances
home-to-work trips, destined to PD1
all modes

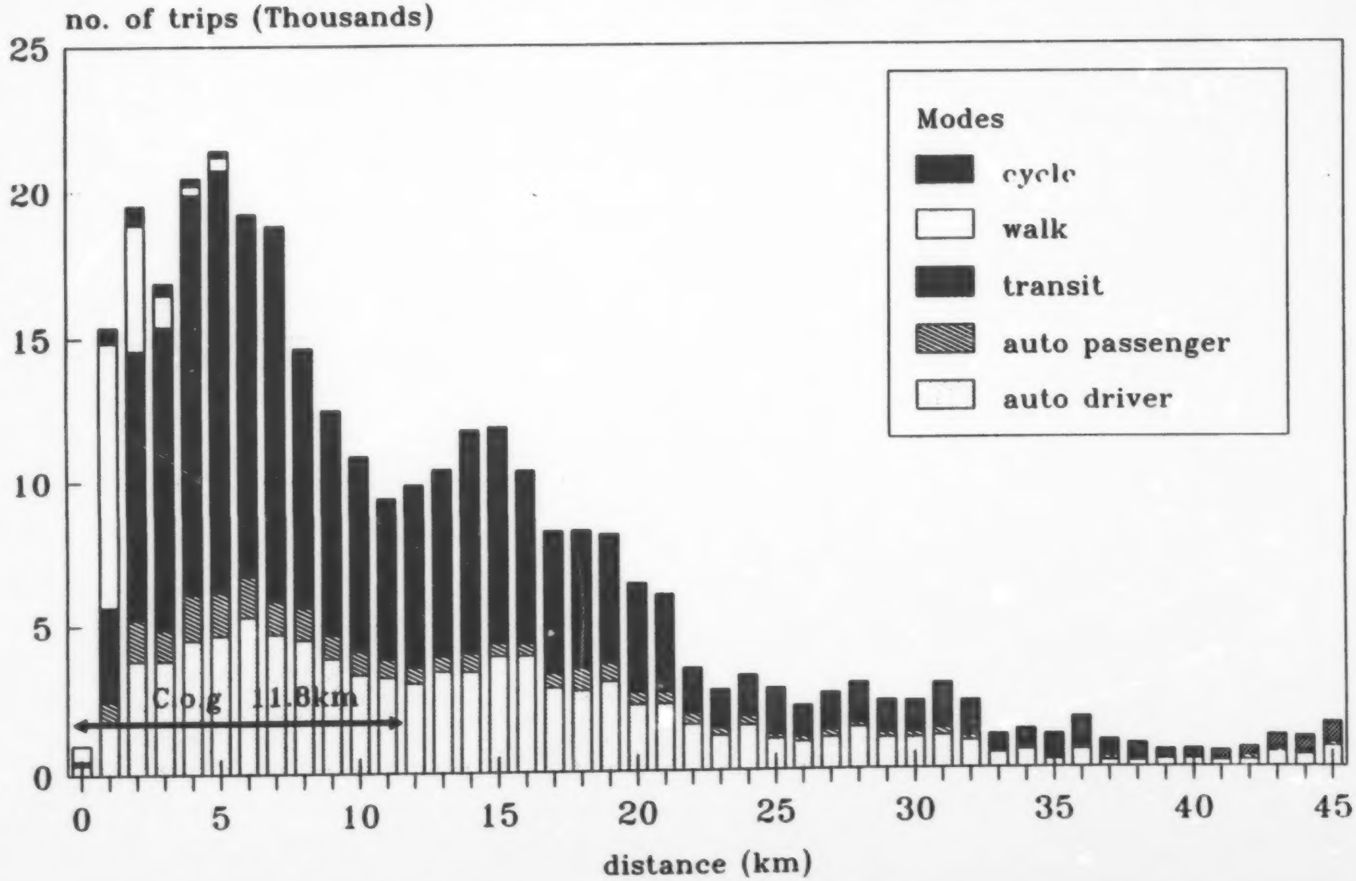


Figure 5.14

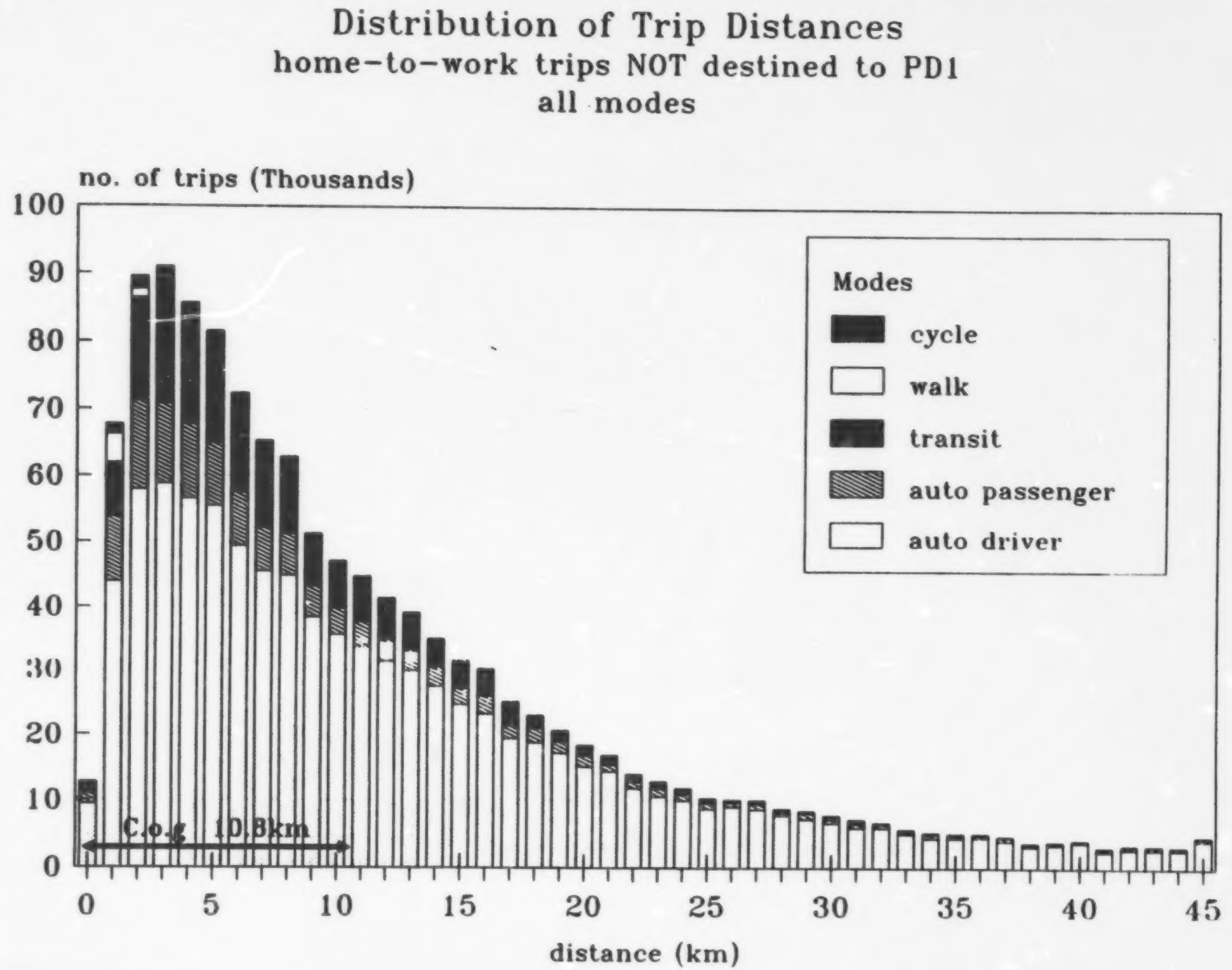

Distribution of Trip Distances
home-to-work trips NOT destined to PD1
all modes
no. of trips (Thousands)
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
distance (km)
C.o.g 10.8km
Modes
cycle
walk
transit
auto passenger
auto driver

Figure 5.15

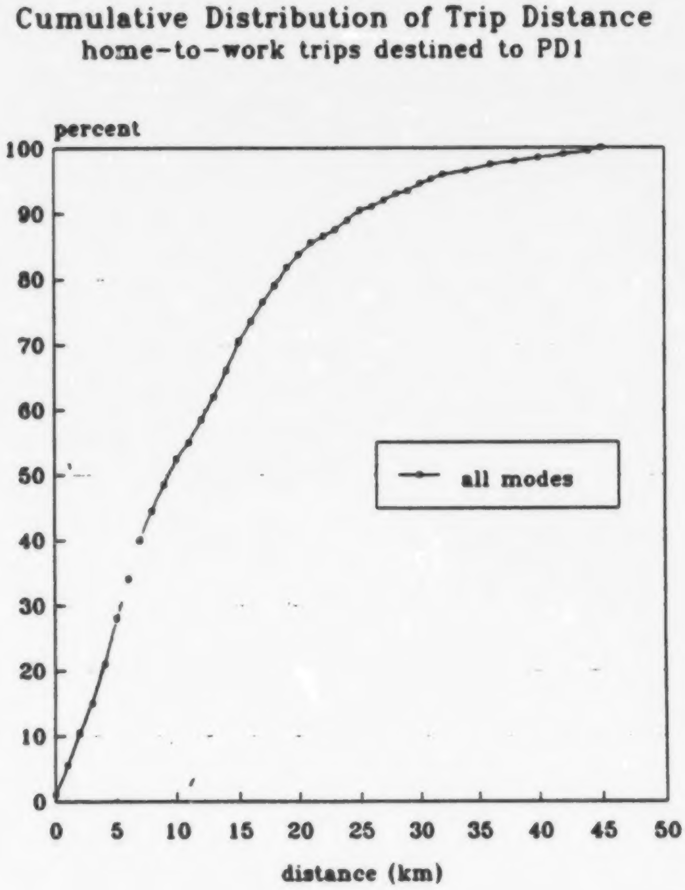

Cumulative Distribution of Trip Distance
home-to-work trips destined to PD1
percent
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
50
distance (km)
all modes

Figure 5.16

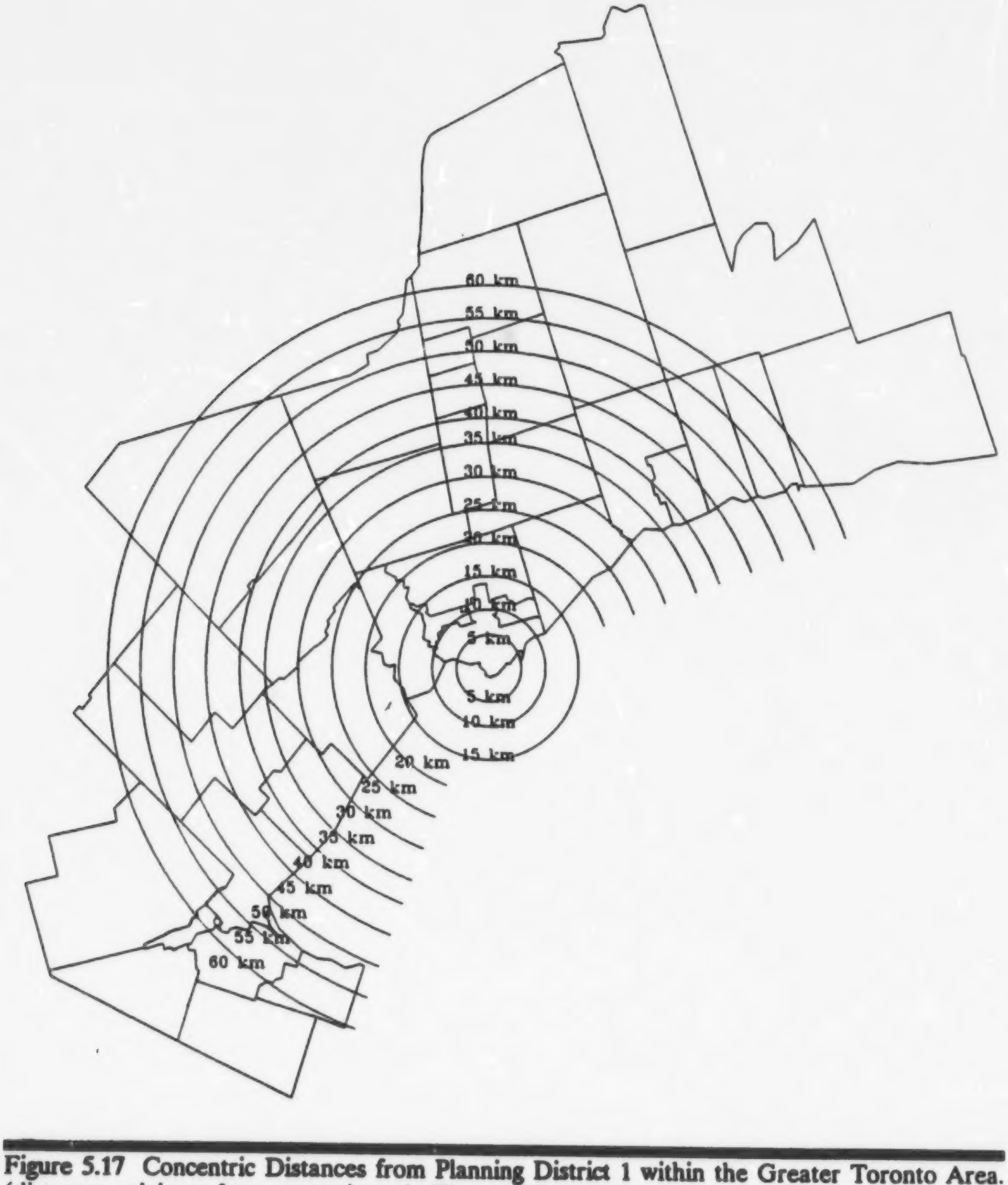


Figure 5.17 Concentric Distances from Planning District 1 within the Greater Toronto Area. (distances originate from approximately King and Bay Sts.)

concentric distances from Bay and King Sts. in Planning District 1 for the Greater Toronto Area. The 95th percentile commuter is 31 km from the central city and thus 16,000 workers are travelling further than 31 km each day to reach downtown employment. There would naturally be a large travel time difference for these commuters depending on their exact location. The centres of gravity of the two distributions indicate that trip makers to PD1 are travelling slightly further to PD1 (approximately 10%) than workers in other locations, as hypothesized earlier.

5.5 Trip Rates by Age

Limited socio-economic data are available in the TTS survey. It is thus somewhat difficult to use this database to construct profiles of trip makers' characteristics. The age of the trip makers, however, was collected and allows a commuter age profile to be formulated. The rate in all cases is based on the total number of people in that age category in the specific area.

The overall trip rate by age for home-to-work trips to PD1 is presented in Figure 5.18. The distribution peaks in the late twenties and declines gradually to the mid fifties, where it drops precipitously. Younger female workers tend to have a higher trip rate than older females. The peak is at approximately 25 years and the distribution then drops quickly, whereas the rate for men peaks later at thirty and declines gradually with age. The female rate actually exceeds that for men until nearly age thirty. This higher female peak lasts longer for Metropolitan Toronto, until 34 (Figure 5.19), and in North York, for example, continues until about forty (Figure 5.20).

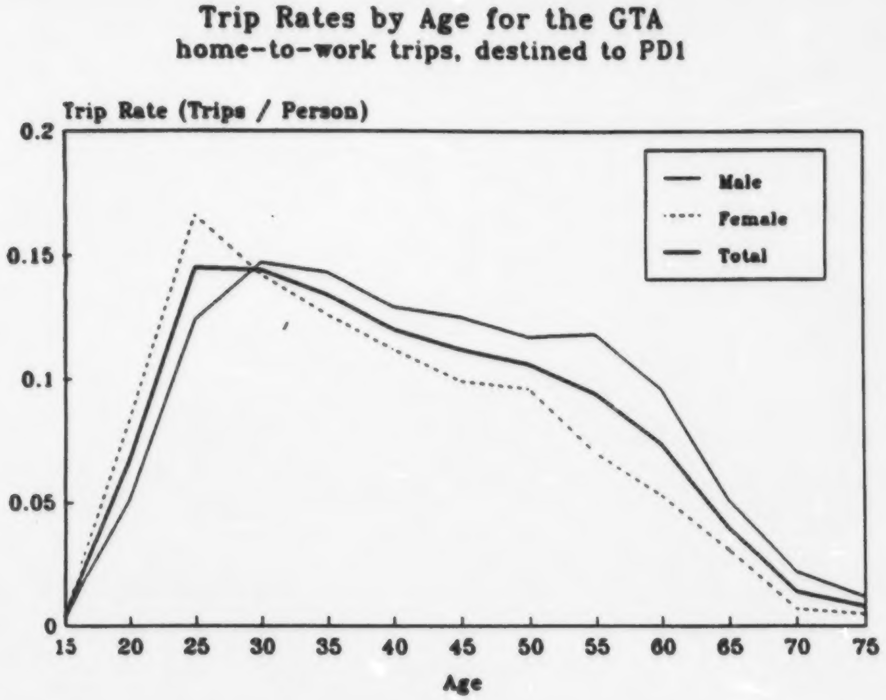
Two hypotheses have been formulated to account for the higher female trip rate. One is that it could be the result of a difference in generations. Thirty year old women would have been born in 1956 and thus they would be part of the mid "baby boom" generation. They would hence likely be more inclined to take more of the higher status downtown jobs than earlier generations. Those women born before this period might prefer lower status local employment while their male spouse travelled further to get better work. These younger women would also normally feel more comfortable in the "downtown" environment than the older generation. Thus with time the higher female trip rate may extend increasingly further along the distribution and hence more areas might approach distributions comparable to North York.

An alternative view is that there is more female employment available in lower status sales and clerical positions in the downtown core and these jobs are much more likely to be filled by younger women. Those women would also likely live closer to downtown, that is within Metro Toronto or the Cities of Toronto, York or the Borough of East York, since these jobs are not well paying and so will not tend to attract women who live at greater distances from PD1.

A clustering of women who work in the central area in adjacent, high density residential areas was also discovered by Wolforth in his investigation of Vancouver. [Wolforth, 1965] He found disproportionate numbers of clerical, sales and service workers living in the West End of Vancouver, which is such an area. The majority of people in these work groupings are younger women. The bias towards transit use and a desire to reside where transit service is better could explain this tendency.

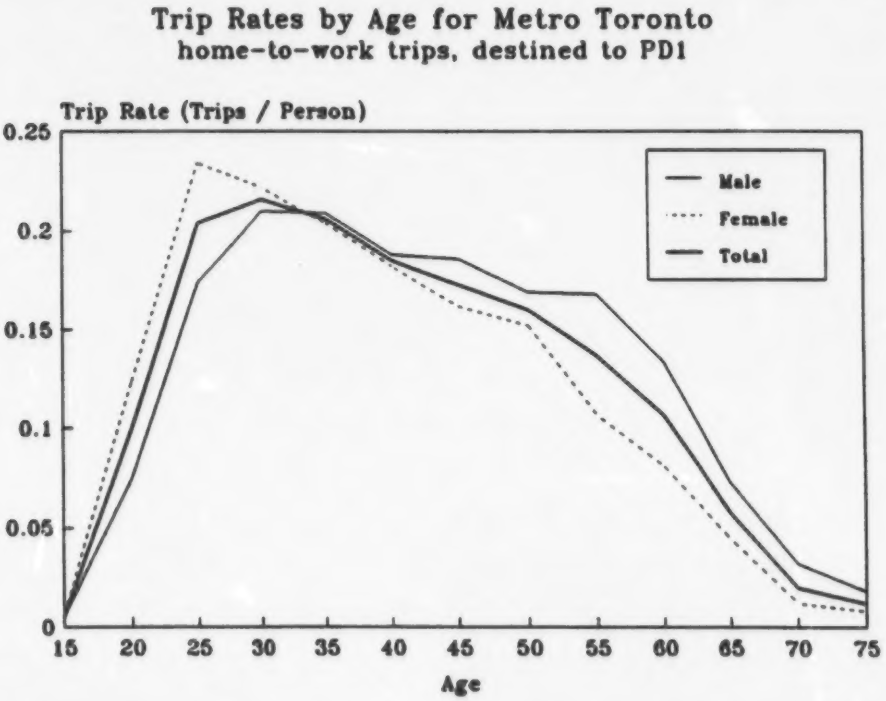
The regional municipalities display a different pattern. The younger segment of women, with higher trip rates, is still present until the mid to late twenties. The female trip rate to Planning District 1 then plunges dramatically while the male rate increases significantly until approximately fifty. The most pronounced effects can be seen in Halton and Durham (Figures 5.21 and 5.22). Older males, who become executives, are transferred downtown as part of promotions or professional men who choose to live in the suburbs and commute are likely in evidence here. In the meantime, the females are more likely to get local jobs or drop out of the labour force to raise children, particularly in the regions where more traditional family structures are more common.

An exception to this analysis is seen in Hamilton-Wentworth (Figure 5.23). As discussed earlier, commuting from Hamilton to Toronto's downtown is a relatively new phenomenon brought about by growth in the GTA. The people who tend to choose this



Trip Rates by Age for the GTA
home-to-work trips, destined to PD1

Figure 5.18



Trip Rates by Age for Metro Toronto
home-to-work trips, destined to PD1

Figure 5.19

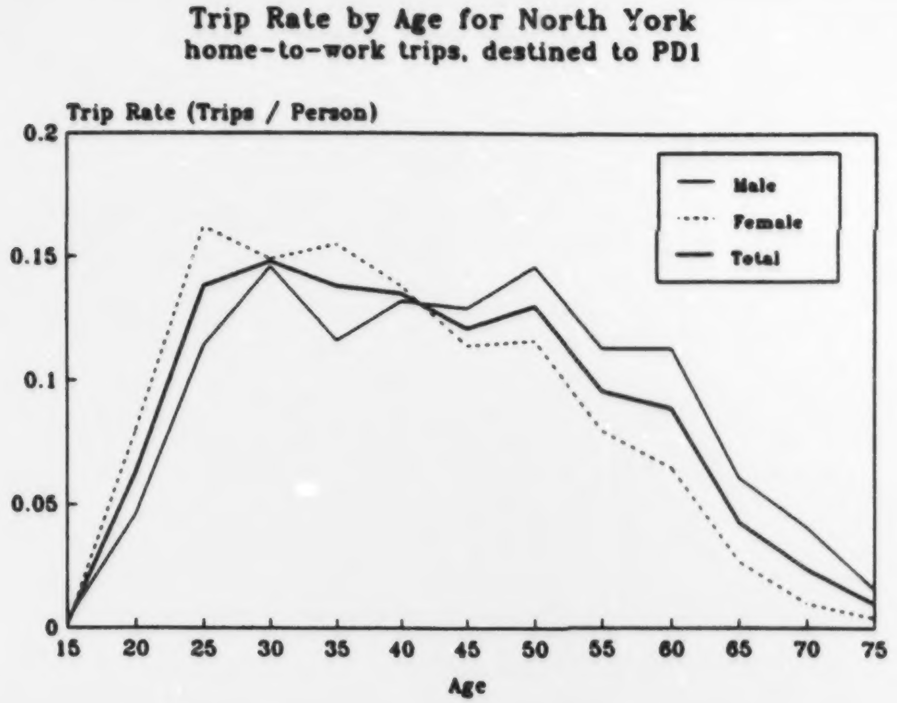


Figure 5.20

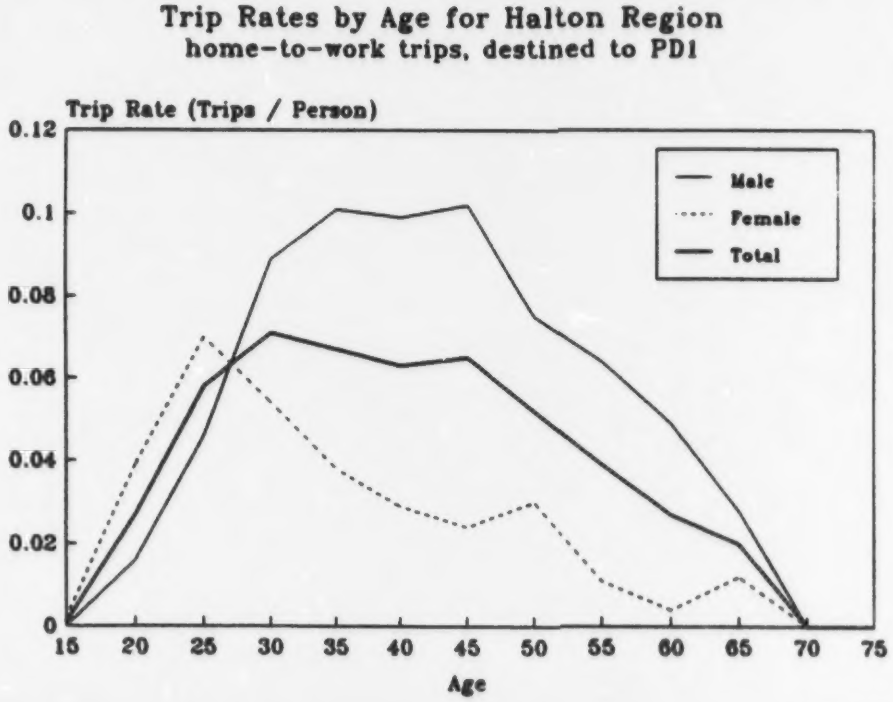


Figure 5.21

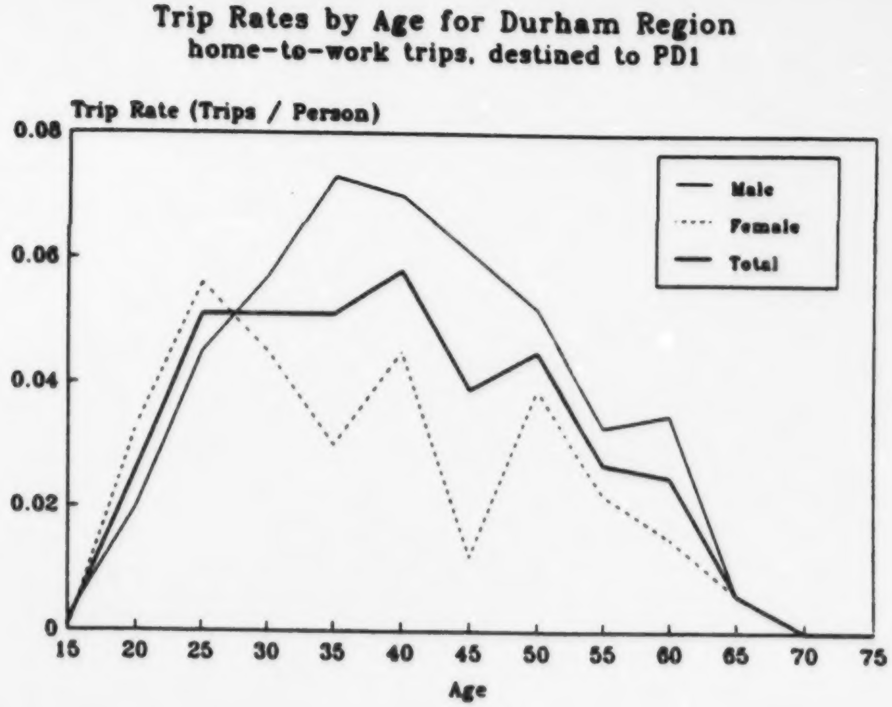

Trip Rates by Age for Durham Region
home-to-work trips, destined to PD1

Figure 5.22

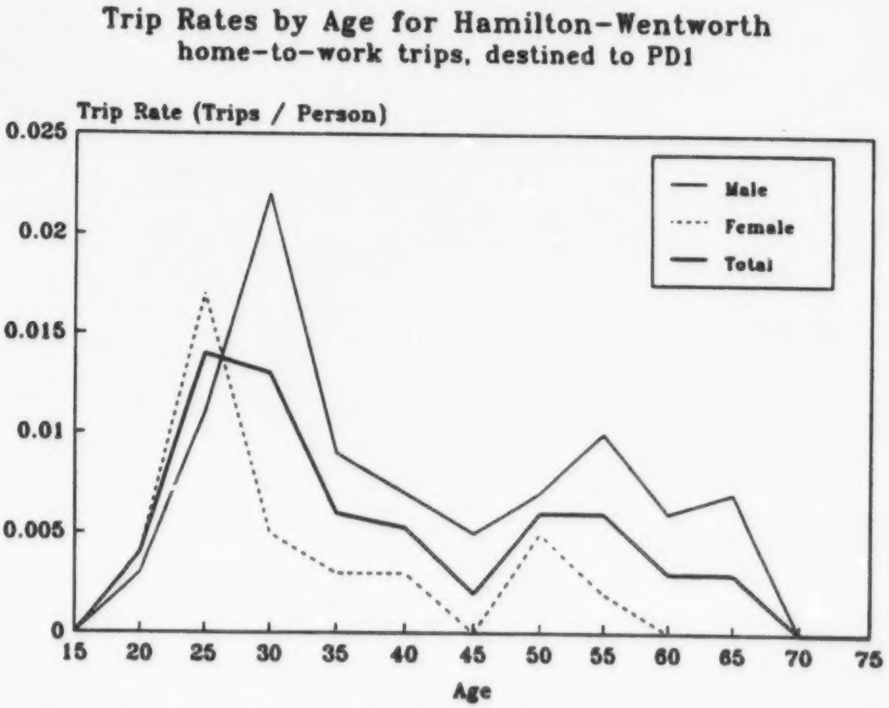

Trip Rates by Age for Hamilton-Wentworth
home-to-work trips, destined to PD1

Figure 5.23

lifestyle are also quite young, with the peak age range of approximately thirty. The difference between the sexes is also much smaller, again indicating a new generation's attitudes. The older generation likely did not have the need to commute to Toronto, finding ample opportunity in Hamilton-Wentworth, which was considered a "self-contained" urban area.

5.6 Modal Choice Variations across the GTA

Toronto is a large metropolitan area, with a complete set of transportation alternatives available to its trip markers. The choices are most complete with respect to transport into the downtown core. Choices include expressways, arterial roads, commuter rail and buses, subways and local surface transit. Spatially across the GTA some modal choices are clearly far superior to others, particularly, as expected, in transit and highway corridors. The extent of this effect in terms of mode split and distance from the facility can be investigated using the TTS data.

Five modes were developed for this analysis based on the primary modes defined in the survey. These modes are auto driver, auto passenger, transit, walk and cycle. The auto driver mode is a combination of people who travelled during their entire trip to Planning District 1 as the driver of an automobile or motorcycle. Auto passengers are people who classified themselves as such within the survey. They are driven on the entire trip to work. The driver of a car with an auto passenger thus is classified as an auto driver. This mode also includes people who took taxis all of the way to work. No differentiation is made for people who use a formal or informal vanpool or carpool or for the occupancy of any of the vehicles carrying auto passengers. Transit trips to PD1 are considered to have occurred if any part of the trip was performed by transit. In many cases this also involves using another mode to access the transit system, including driving or being driven to a passenger drop-off location, bus stop or park and ride lot. Transit consists of buses, streetcars, subways or commuter trains. The walk and cycle mode specification consists of people who use this mode only for the entire trip to work. People who refused responses, listed their modes as "other" or took school buses to work (other options in the TTS database) were excluded from the analysis. These people represent only 0.09% of the sample.

The five outer regions are extremely consistent overall in mode split. Approximately one-half, 50 to 53%, use some form of transit, 39 to 44% travel as an auto driver and 7 to 8% travel as auto passengers, excluding Hamilton-Wentworth where a small sample likely led to under reporting of auto passengers (Figure 5.24). The overall transportation options available to each regional municipality for trips to PD1 appears to be quite similar. This implies no one region appears to be served significantly better then the others by one mode of transportation.

In Metro Toronto the situation is, as expected, quite different. The more extensive transit system and the flat fares throughout the regional municipality encourage more transit use. Interestingly the overall transit split only rises from seven to ten percent higher than outside of Metro where transit service is generally inferior. The level of auto passenger trips are again similar to those outside Metro, approximately seven percent. The propensity to be an auto passenger seems to be independent of location.

The repeatability of the auto passenger results warrants further investigation. Auto passengers can represent a wide cross section of travel choices. They can be co-workers who live in relatively convenient locations and are thus able to share a ride, or a couple, neighbours or friends who work in a location that is mutually convenient to allow one to drive the other(s) to work. This mode would usually involve adjusting or restricting one's schedule to facilitate the others in the group. The arrangement can range from an informal understanding to a shared ownership, formal vanpool. As transit service is apparently equivalent and generally available to all regions this is largely "a choice" mode for trips to the central area of Toronto. Apparently the congruence of travel patterns, schedules and residences is just as likely to occur in almost any part of the GTA.

A priori one might expect auto passengers to be primarily an outlying, rural effect in areas without reasonable transit service. Perhaps this is the case in areas that are distant

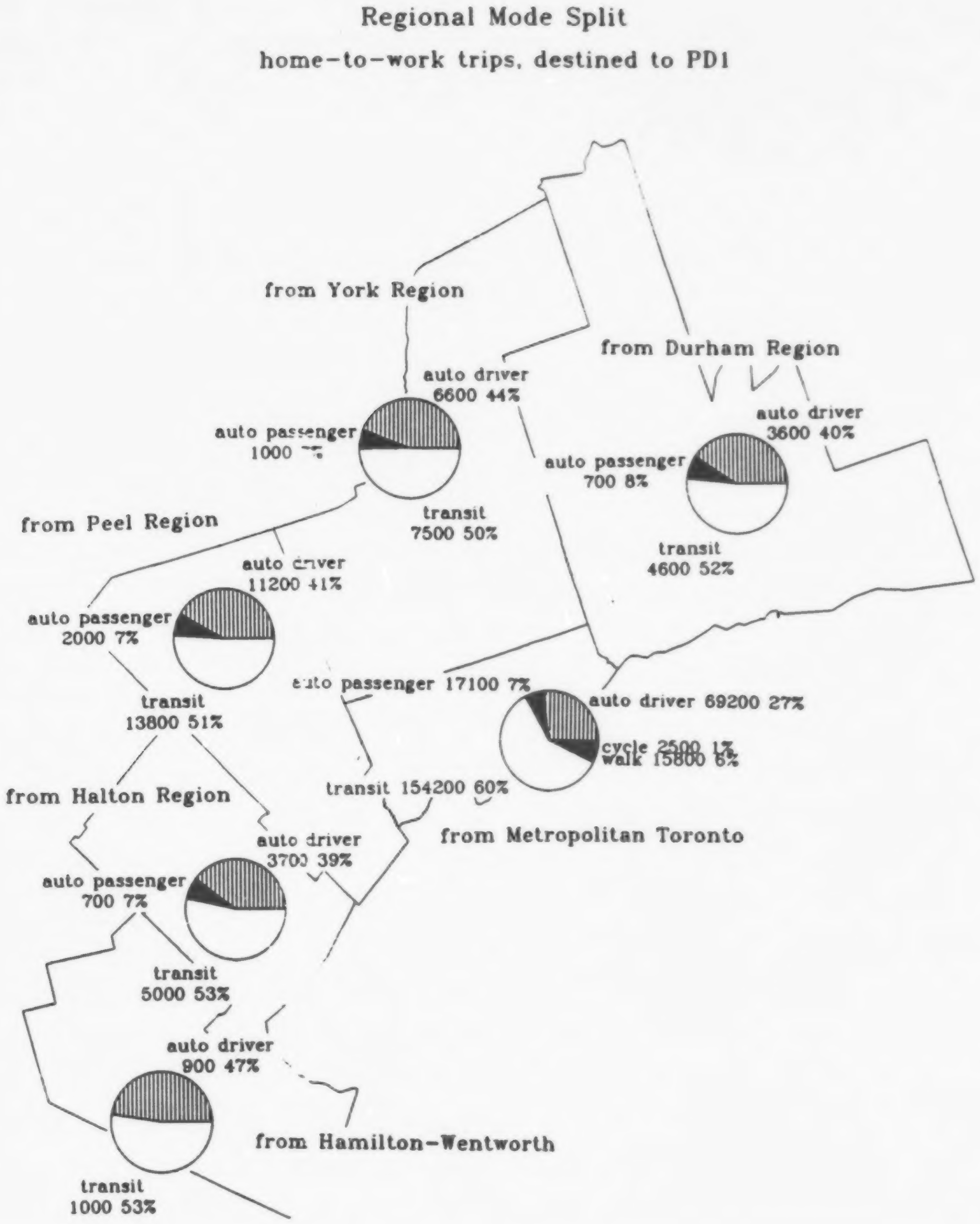

Regional Mode Split
home-to-work trips, destined to PD1
from York Region
auto driver
6600 44%
auto passenger
1000 7%
transit
7500 50%
from Durham Region
auto driver
3600 40%
auto passenger
700 8%
transit
4600 52%
from Peel Region
auto driver
11200 41%
auto passenger
2000 7%
transit
13800 51%
auto passenger 17100 7%
auto driver 69200 27%
cycle 2500 1%
walk 15800 6%
transit 154200 60%
from Metropolitan Toronto
from Halton Region
auto driver
3700 39%
auto passenger
700 7%
transit
5000 53%
auto driver
900 47%
from Hamilton-Wentworth
transit
1000 53%

Figure 5.24

from the central city. Here the onerous drive and poorer transit service may encourage more effort to form carpools. In the areas closer to the city the more numerous commuters heading to the central area makes it much easier to find a partner for those who wish to pool. Thus the overall effect leads to similar percentages of auto passengers in all areas.

Finally, near Planning District 1 there is a significant walk component and also a numerically large cycle component. The number of people who cycle is small when compared to Metro values but greater than, for example, all the commuters from Hamilton-Wentworth. The large magnitude of the values within Metro, 81% of all the commuters, makes the overall mode split for the GTA, for home-to-work trips destined to PD1, approach the values indicated for Metro. Therefore within the Greater Toronto Area 58% of the home-to-work trips to Planning District 1 are by transit, 30% by auto drivers, 7% travel as auto passenger, 5% walk and 1% cycle.

The transit trip rates by age reveal female trip rates that are almost 60% higher than male trip rates (Figure 5.25). The peak age for women is approximately 27 years. Women for various historical and customary social reasons use transit more than their male counterparts in all age categories. This has been documented in the Canadian Transit Handbook. [Canadian Urban Transit Association, 1985] Men use transit at a more constant rate over the years, whereas young women are particularly heavily transit users. Likewise auto passengers are also much more likely to be women on home-to-work trips to PD1 (Figure 5.26). The female auto passenger rates are twice those for males. Conversely, men are three times more likely to be auto drivers to PD1 than women (Figure 5.27). These modal biases all follow a priori reasoning.

The total number of trips, by mode, destined to PD1 from each region is displayed as Figures 5.28 to 5.30. The five suburban regions produce 27% of the auto drivers destined to PD1 on home-to-work trips, 20% of the auto passenger and 17% of the transit trips. They also represent 19% of the GTA, home-to-work, PD1-destined trip makers. Thus, the regional commuters are undeniably more dependent on the auto driver mode then Metro Toronto commuters.

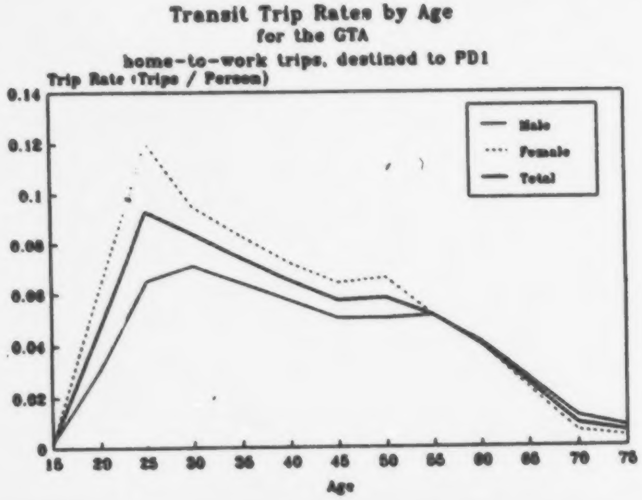


Figure 5.25

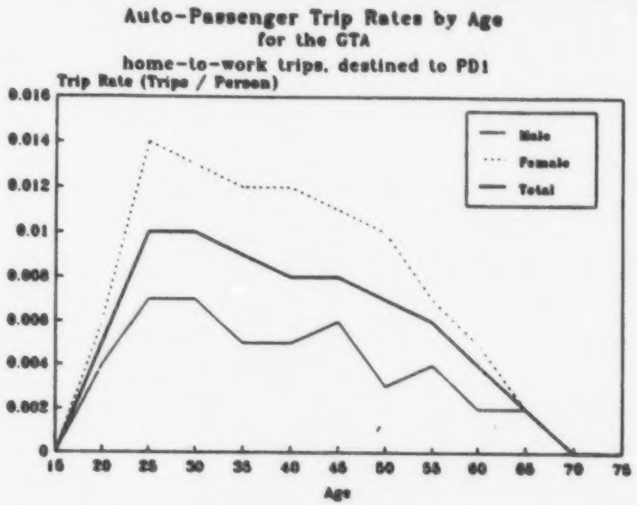


Figure 5.26

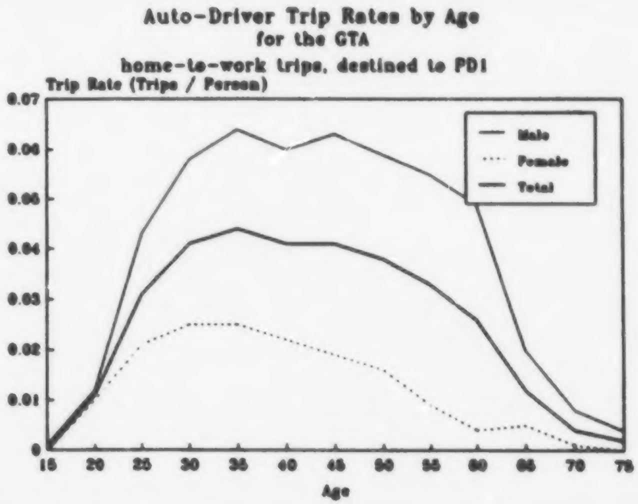
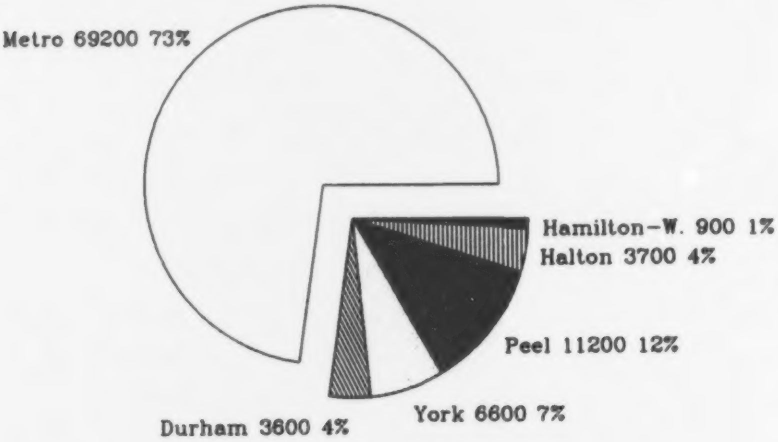


Figure 5.27

Proportion of Auto-Driver trips
generated by each Region

home-to-work trips, destined to PD1



Identifying Metro Toronto Municipalities

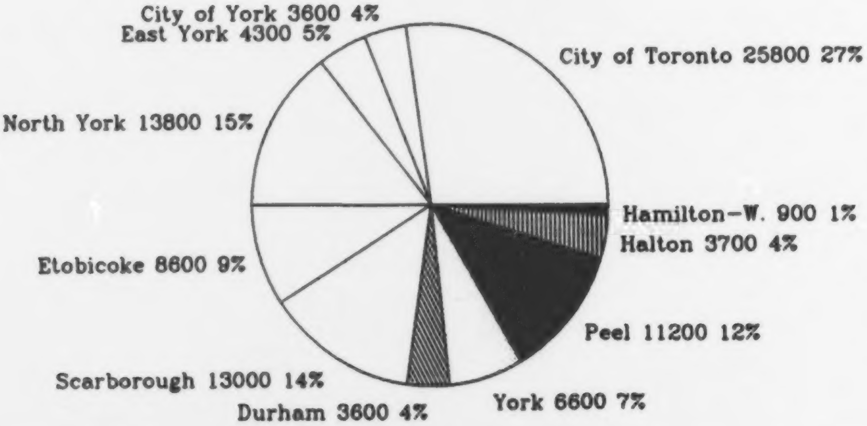
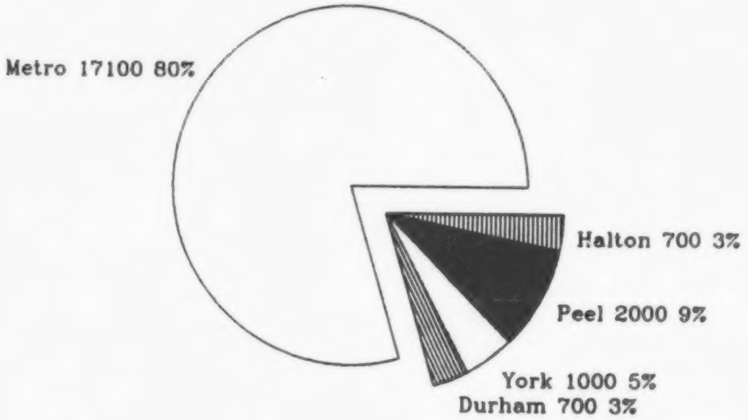
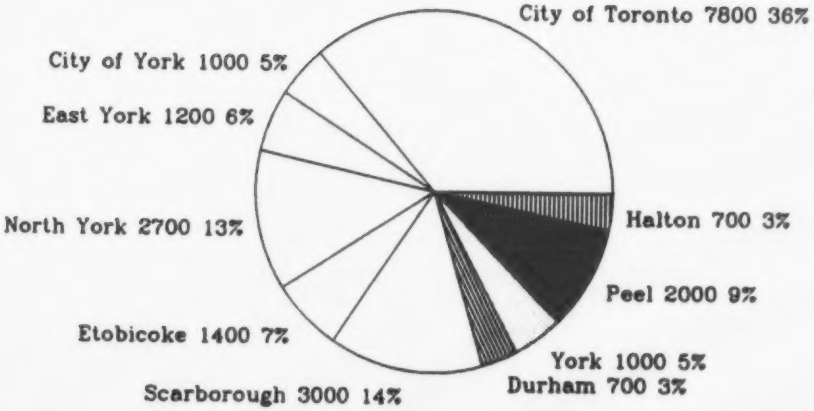


Figure 5.28



Proportion of Auto-Passenger Trips generated by each Region

home-to-work trips, destined to PD1

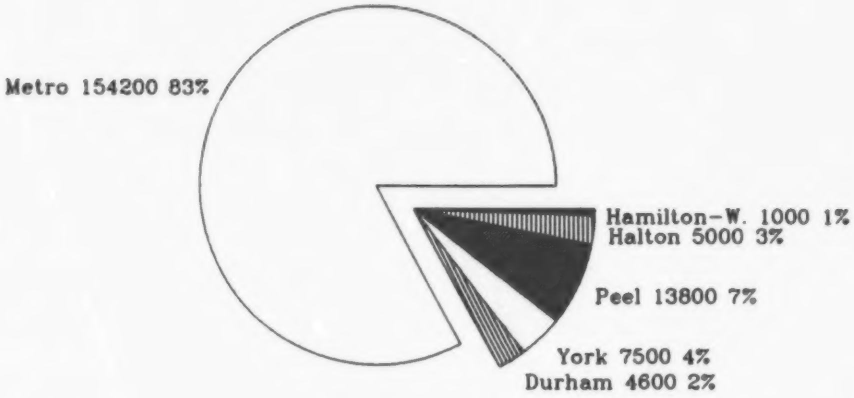


Identifying Metro Toronto Municipalities

Figure 5.29

Proportion of Transit Trips
generated by each Region

home-to-work trips, destined to PD1



Identifying Metro Toronto Municipalities

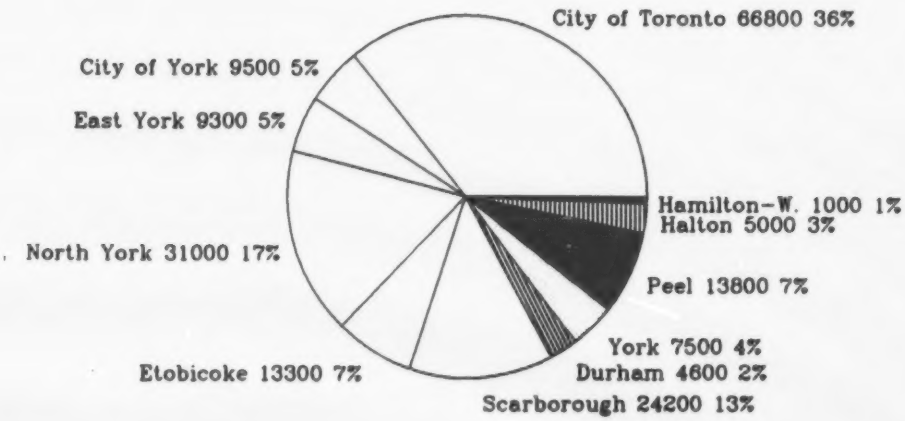


Figure 5.30

Three quarters of all the cars coming into PD1 are, however, still coming from within Metro Toronto, or 70,000 vehicles. Many of these vehicles will tend to use the arterial road network rather than the major expressways to get downtown as they are diffused over a wide area within Metro. As is seen later in the discussion of the spatial distribution of auto drivers however, much of the auto driver use is concentrated in the highway corridors along the Don Valley and Highway 401 in Scarborough and Etobicoke. Thus much of the highway auto traffic is originating within Metro.

These results imply that an effort to increase the five-region PD1 mode split to 60% for transit, a 10% increase, would remove 5000 vehicles from Metro Toronto roads. Conversely, a transit mode increase in Metro of only half the 10%, up to 65%, would remove 14,000 vehicles, or three times the regional value. Even a massive 20% regional transit mode split increase to 70% would remove 12,000 auto drivers and this would still be fewer than a 5% increase within Metro. These statements, of course, neglect the potential growth occurring in the regions and that, as stated earlier, the non-Metro share of PD1 home-to-work market is likely growing.

5.6.1 City of Toronto Mode Split

Within the City of Toronto, four sectors were developed for the analysis of modal variations. They are Planning District 1; Eastern Toronto, the area east of PD1 but still within the City and approximately half of Planning District 6; Northern Toronto, the area north of PD1 but within the City and half of Planning District 4; and Western Toronto, the area west of PD1 and most of Planning District 2 and a small part of Planning District 3.

The three outer sectors generally show similar results but some differences are evident (Figure 5.31). In particular, transit usage is noticeably lower in Eastern Toronto, which has a transit share of 59%, compared with 64% and 69% in the north and west respectively. This results in generally higher level of use of auto-based modes in Eastern Toronto. Twenty-eight percent of the commuters are auto drivers, which is equal to the value in the north, and eleven percent travel as auto passengers. This is twice the amount in the north and 4% higher than the west. The more common use of auto-based modes in

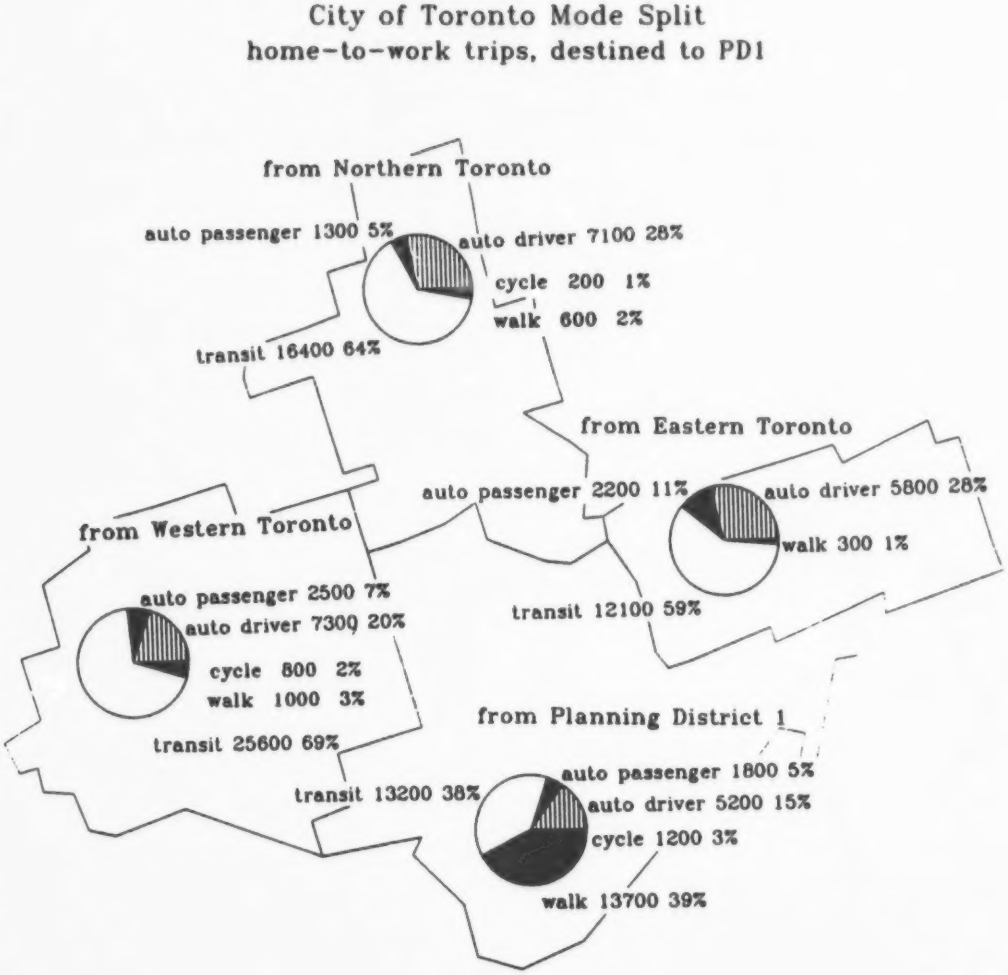

City of Toronto Mode Split
home-to-work trips, destined to PD1
from Northern Toronto
auto passenger 1300 5%
auto driver 7100 28%
cycle 200 1%
walk 600 2%
transit 16400 64%
from Eastern Toronto
auto passenger 2200 11%
auto driver 5800 28%
walk 300 1%
transit 12100 59%
from Western Toronto
auto passenger 2500 7%
auto driver 7300 20%
cycle 800 2%
walk 1000 3%
transit 25600 69%
from Planning District 1
auto passenger 1800 5%
auto driver 5200 15%
cycle 1200 3%
walk 13700 39%
transit 13200 38%

Figure 5.31

the east end of Toronto, which socio-economically is not generally assumed to be wealthier than the west and certainly not the north, is unexpected.

This could be the result of an inferior level of transit service in the east. East-west transit service is primarily provided by two main streetcar lines, along Gerrard and Queen Sts. The Queen line is plagued by delays due to on street traffic. These people also live south of the subway, and if they wish to use it to get downtown they therefore have to take a bus north, use the subway to go west and then take the Yonge or University subway south again to reach the centre of downtown. Thus they are forced to backtrack on their trip. Conversely, the west end of the City of Toronto is served by four streetcar lines and a bus route.

The other notable effect is the higher auto driver split from the more wealthy areas in Northern Toronto and the lower split from the less wealthy area in the west.

Within PD1 it is significant to note the number of trips using the walk mode. This is the largest single mode in PD1 and used by 40% of the local residents who work in the central area. The proximity to work allows many who would normally take transit to walk instead. Compared to people who live in the other sectors of the City and work within the some sector (Figure 5.32), generally one-third of the residents walk to work throughout the City. The highest value, however, still occurs within Planning District 1. It is interesting to note how quickly the use of auto-based modes rises outside of PD1 while transit use declines. In Northern Toronto, for local work trips, only one in five trips are by transit while the transit service is still quite extensive. This again reinforces the extent to which the transit system is focused on the central area.

Cycling generally represents below three percent of all work trips in any sector of the City. Spatially the values are also too small for conclusions to be made. Cycling is still likely a significant mode of transport within the city, however. This mode is difficult to sample due to the small number of users. A stratified sample may be more useful than a

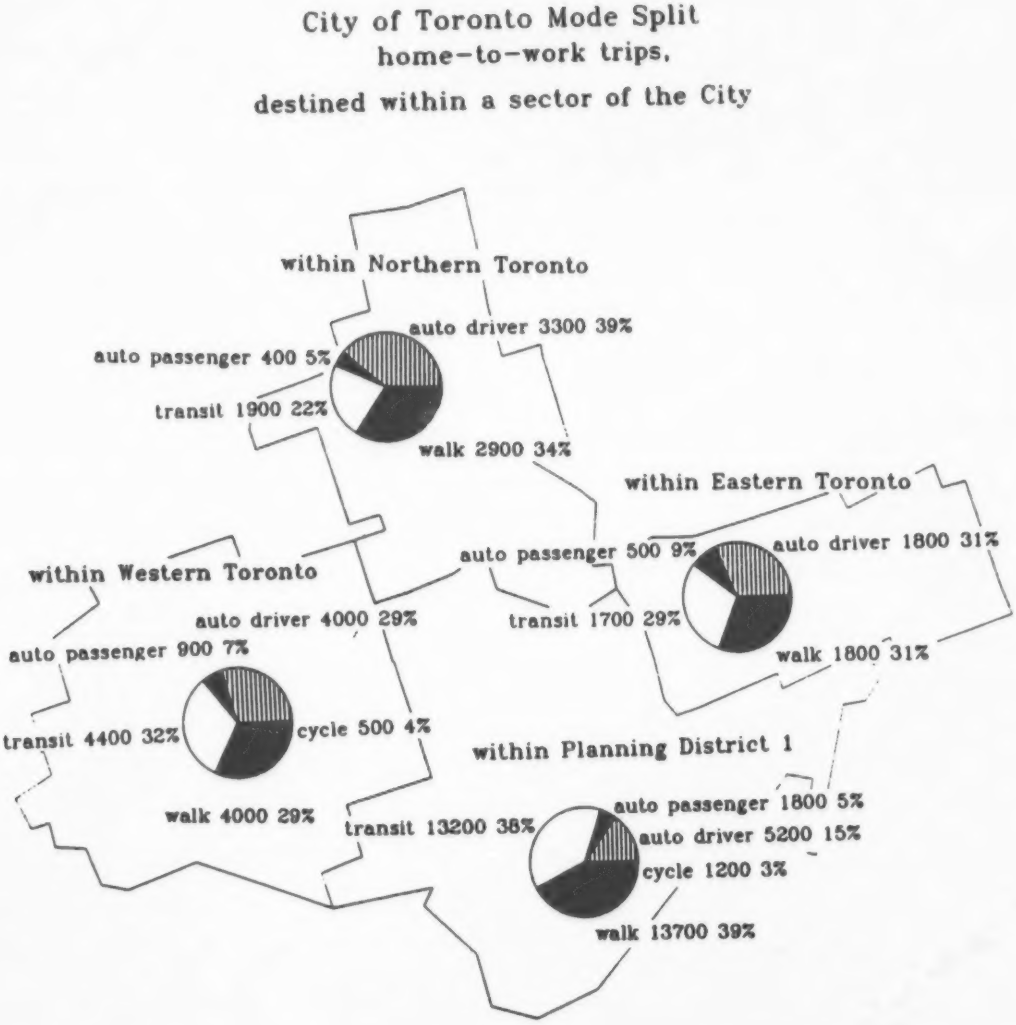

City of Toronto Mode Split
home-to-work trips,
destined within a sector of the City
within Northern Toronto
auto driver 3300 39%
auto passenger 400 5%
transit 1900 22%
walk 2900 34%
within Eastern Toronto
auto passenger 500 9%
auto driver 1800 31%
transit 1700 29%
walk 1800 31%
within Western Toronto
auto driver 4000 29%
auto passenger 900 7%
transit 4400 32%
cycle 500 4%
walk 4000 29%
within Planning District 1
auto passenger 1800 5%
auto driver 5200 15%
transit 13200 38%
cycle 1200 3%
walk 13700 39%

Figure 5.32

four percent sample of all residents. Also, as the survey was performed in the fall and early winter, fewer people would be using this mode than in the spring or summer.

The consistency of the auto passenger trips for journeys within the sectors and journeys to PD1 from within the sectors should be considered as additional evidence that location is not a limiting factor in choosing this mode.

Finally, the magnitude of the numbers of commuters involved in home-to-work trips within the City is striking. One-half of all home-to-work trips in the City are destined to PD1 and this represents 37% of PD1 employment or 118,000 trips. A relatively strong match of City residences with PD1 employment exists, as many downtown workers are finding acceptable local homes. Thus the city is not being avoided by downtown workers in search of homes.

One quarter (27%) of the auto drivers travelling to PD1 are still coming from within the City of Toronto. This equates to 25,000 cars (refer to Figure 5.28). Thus, even though the City has the most elaborate and dense transit network in the GTA, which produces one-third of all PD1 destined, home-to-work transit trips and has an enviable 71% non-auto-based mode split, 25,000 cars are still being put on city streets by local workers. Thus, efforts to reduce auto usage on home-to-work trips within the confines of the city could still produce major reductions in the levels of auto traffic.

5.6.2 Spatial Distribution by Mode within Metropolitan Toronto

Expanding the modal analysis outside of the City of Toronto allows several important spatial trends to be observed within Metro Toronto (Figures 5.33 and 5.34). Auto drivers tend to be a higher proportion of the home-to-work trips in a diagonal line from PD1 to the northeast which follows the Don Valley (i.e., the Don Valley Parkway). This is a non-continuous band which shows a mixture of values. The effect only continues as far north as the 401 then abruptly ends. There are, however, no apparent demographic or housing stock differences across the 401 that should account for this difference. The higher auto driver band then continues across northern Scarborough in the zones adjacent to the 401,

Proportion of Trips destined to PD1 within Metro Toronto
home-to-work trips, as an auto driver

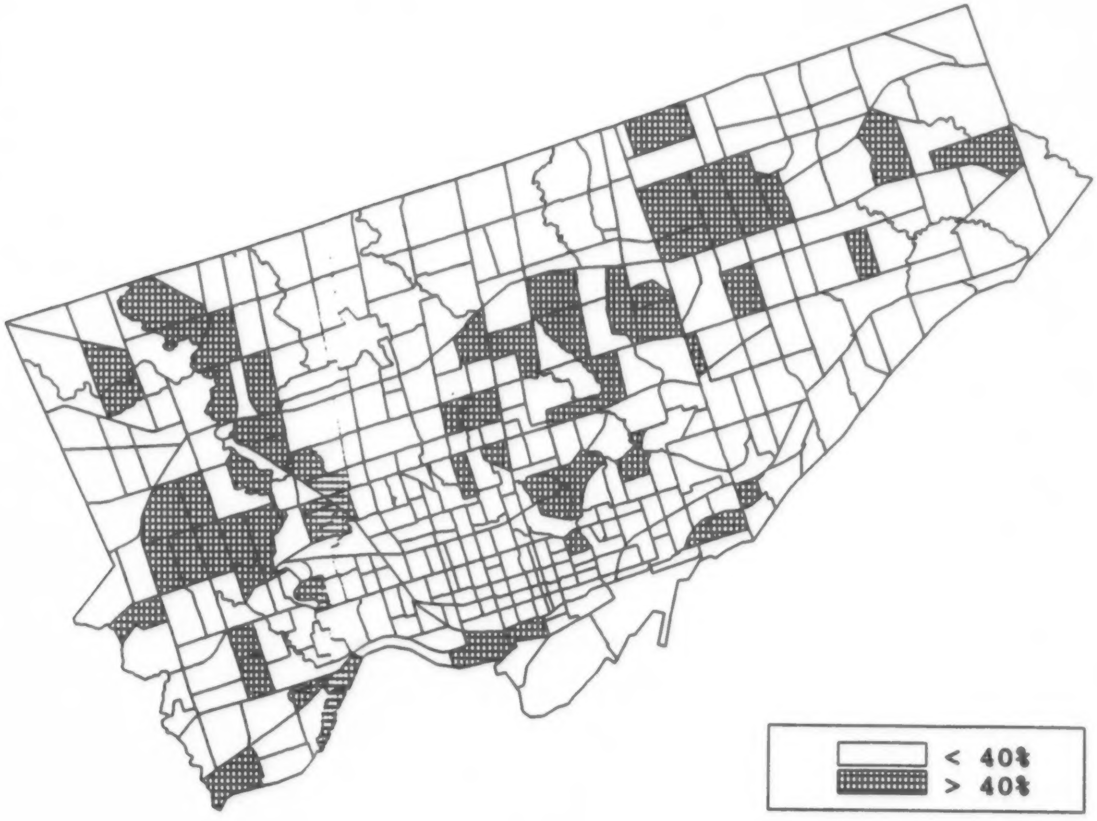


Figure 5.33

Proportion of Trips destined to PD1 within Metro Toronto
home–to–work trips, by transit

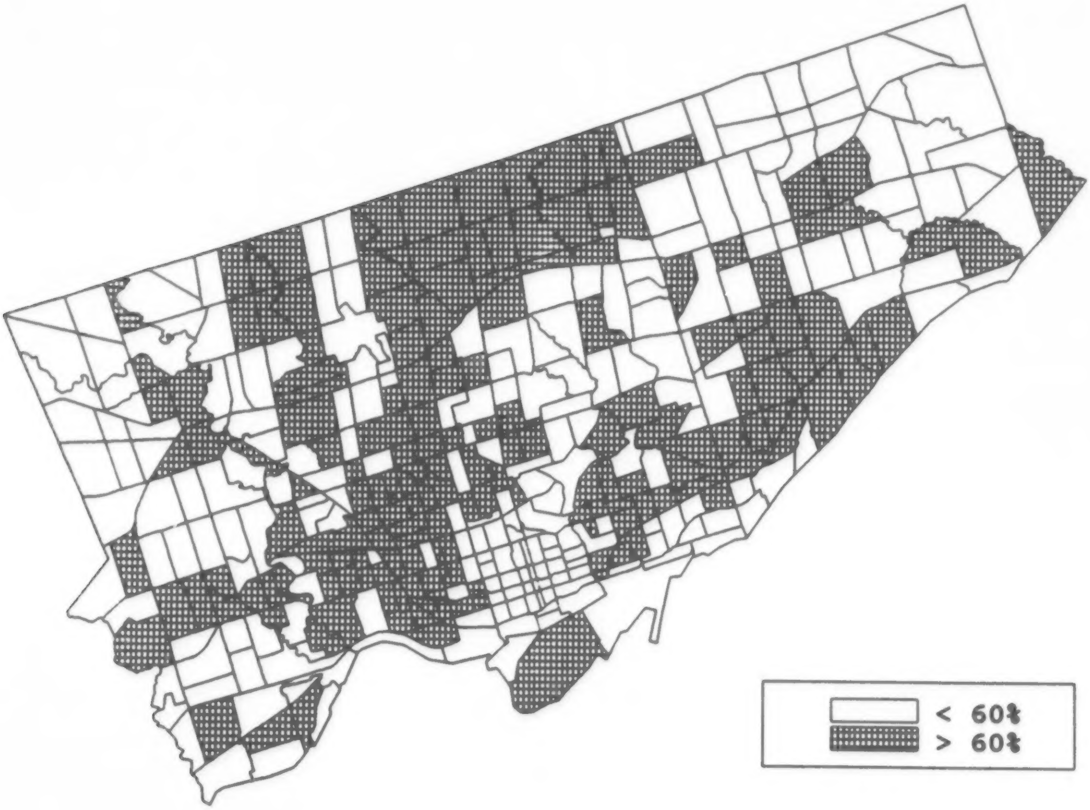


Figure 5.34

particularly on the north side. Zones adjacent to the 401 are 10% higher in auto driver usage than those not adjacent (38% vs. 28%). Evidently, proximity to highway access to PD1 is encouraging auto drivers in the northeast and the Don Valley corridor. Many of these zones are in the lower level of PD1 dependence, some less than 20%. This is particularly the case in northeastern Scarborough. Thus generally more diffuse travel patterns or more work locations in other parts of the GTA encourages the use of cars as opposed to areas where more concentrated downtown patterns of travel are apparent.

This effect can be seen when one looks at the Willowdale and Don Mills areas north of the 401. There is a solid block of high levels of transit use from Bathurst St. to Victoria Park Ave. and from the 401 to Steeles Ave. In this 50 km^2 area transit use approaches 70%. The area is north and east of the Yonge and Spadina subway terminals. Interestingly, the eastern areas of the block are still 6 km from the subway and adjacent to the 404 (an extension of the DVP), yet show none of the Don Valley influence analogous to the areas to the immediate south of the 401. The effect also ends abruptly at the North York - Scarborough border (Victoria Park Ave.).

A comparable, but smaller, area is located in southwest Scarborough near the end of the Danforth subway. This is again the area where a higher proportion of the residents are employed downtown. This band of higher transit use extends west along the Danforth into the City but excludes many of the areas to the south in eastern Toronto where transit usage declines and auto based modes are more commonly used, as previously discussed.

Finally, in western Toronto and North York different factors seem to be evident. In the west end of the city transit usage remains high in a block from Planning District 1 west to the Humber River (60 to 80%). Higher transit use also extends north into the City of York and continues into the areas already described as not PD1-dependent in Downsview. These tend to be lower income areas in which transit use may be more of a necessity than in many of the other areas. This is particularly likely in the neighbourhood on either side of Jane St. between Sheppard Ave. and Steeles Ave. Similarly, lower income areas of Malvern, in northeast Scarborough, and south Rexdale, in northern Etobicoke, have higher transit use.

To a lesser extent the high transit use continues west of the Humber River into Etobicoke. The band of high transit use, however, is much more narrow here. Unlike the wide-spread effects seen at the end of the Yonge and Danforth lines the Bloor West line has effects that seem to be more concentrated in the zones immediately north of the subway. These areas average a 70% transit mode split.

Immediately to the north of these highly transit-oriented zones near the Bloor subway transit usage quickly declines. This area includes much of central Etobicoke. These areas average fifty percent use of the auto driver mode. Unusually, these zones are along the bus feeder routes to the subway and are bordered only by a highway to the north. The 401 also has no direct connections with the downtown from the west. Similarly, transit usage is also lower south of the subway in Etobicoke. These areas are close to the Gardiner Expressway. It is also more unrealistic to expect transit users to head north by bus, west to the subway and south again to reach the downtown. This would be a similar situation to the residents in East Toronto who live south of the subway.

The development of clusters of heavily transit dependent zones, particularly adjacent to some rapid transit stations, is also apparent. Such clusters are evident adjacent to Kennedy and Victoria Park stations on the Danforth subway, Sheppard and Eglinton stations on the Yonge subway and High Park stations on the Bloor subway. Within the Sheppard concentration 82% of the home-to-work tripmakers use transit. Similarly, adjacent to Eglinton and Yonge, 73% of the central area commuters use transit, while in the High Park area 85% use transit. The high density housing created for commuters around the subways is obviously effective at encouraging transit use at these locations. These particular markets are also within the bands of higher PD1 dependency. This market is also probably growing as condominium construction is increasing in downtown North York, at Islington and Bloor, and along the subway and RT in Scarborough.

The fact that residents near the subway use transit more is not universal. Along the Yonge subway at York Mills and Lawrence stations transit use to PD1 declines to the 40 to 60% range, while auto driver usage rises to 53% at Lawrence and Yonge and 51% at York Mills. Even though there is some higher density housing (particularly at York Mills) it is not attracting transit users to the extent that can be seen at other locations.

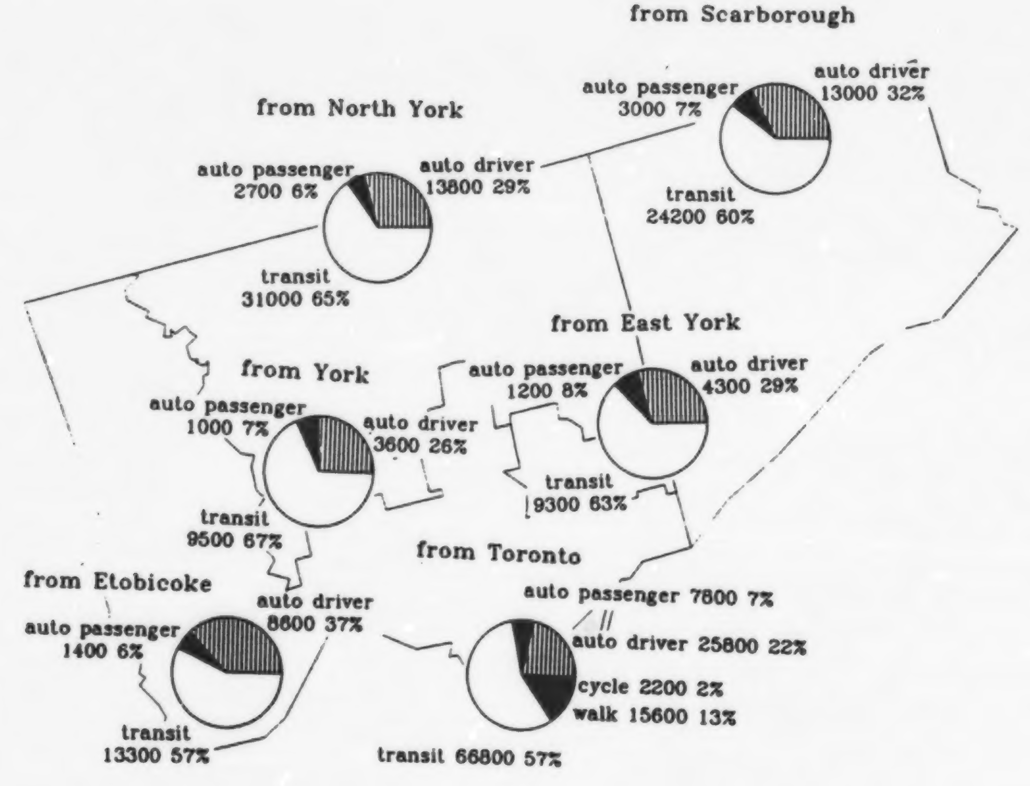
Overall the mode split by municipality within Metro is shown in Figure 5.35.

The spatial distribution of travel mode choices within Metro allows some conclusions to be drawn. Transit users are found in the highest concentrations for home-to-work trips to PD1 in three major areas within Metro: Willowdale, southwest Scarborough and West Toronto. These concentrations do not seem to be based on socio-economics but correspond somewhat to the extremities of three of the four subway lines. This is a result of higher transit availability and not necessarily proximity to downtown. Certain developments along the subway lines have been highly successful at capturing central area workers who are willing to take transit downtown. Thirdly auto drivers tend to be more concentrated in the Don Valley corridor and in the other areas of Metro Toronto previously defined as less PD1 dependent, even though these areas may still produce significant numbers of PD1 trips. This is with the exception of some lower income areas in Downsview and Rexdale.

5.6.3 Spatial Distribution by Mode for the Inner GTA

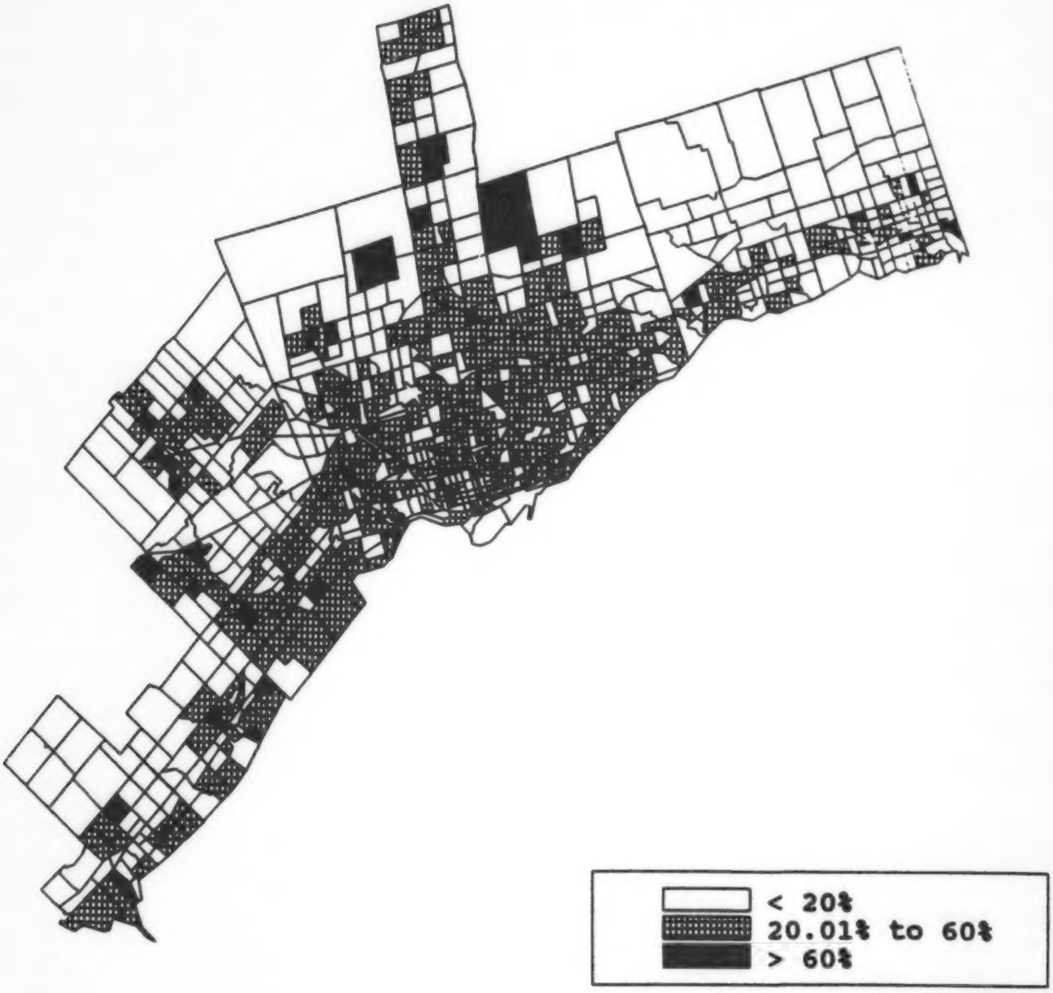
The spatial distribution of mode choices to PD1 for home-to-work trips in the Inner GTA is presented in Figures 5.36 to 5.38. From these figures the modal choices of various areas of the Greater Toronto Area can be examined.

In southwestern Durham Region, as stated earlier, the PD1 dependency declines with increasing distance from Metropolitan Toronto. The use of transit also seems to be primarily dependent on the commuter's location relative to the GO Train station in Pickering. Figure 5.39 illustrates the modal splits for the four municipalities in southwestern Durham Region. The sharp transit decline can also be seen in the graph of PD1 dependency and travel mode for Durham Region (Figure 5.40). As one moves east



Metropolitan Toronto Mode Split
home-to-work trips, destined to PD1

Figure 5.35



Proportion of Trips destined to PD1 within the Inner GTA
home-to-work trips, as an auto driver

Figure 5.36

Proportion of Trips destined to PD1 within the Inner GTA
home-to-work trips, as an auto passenger

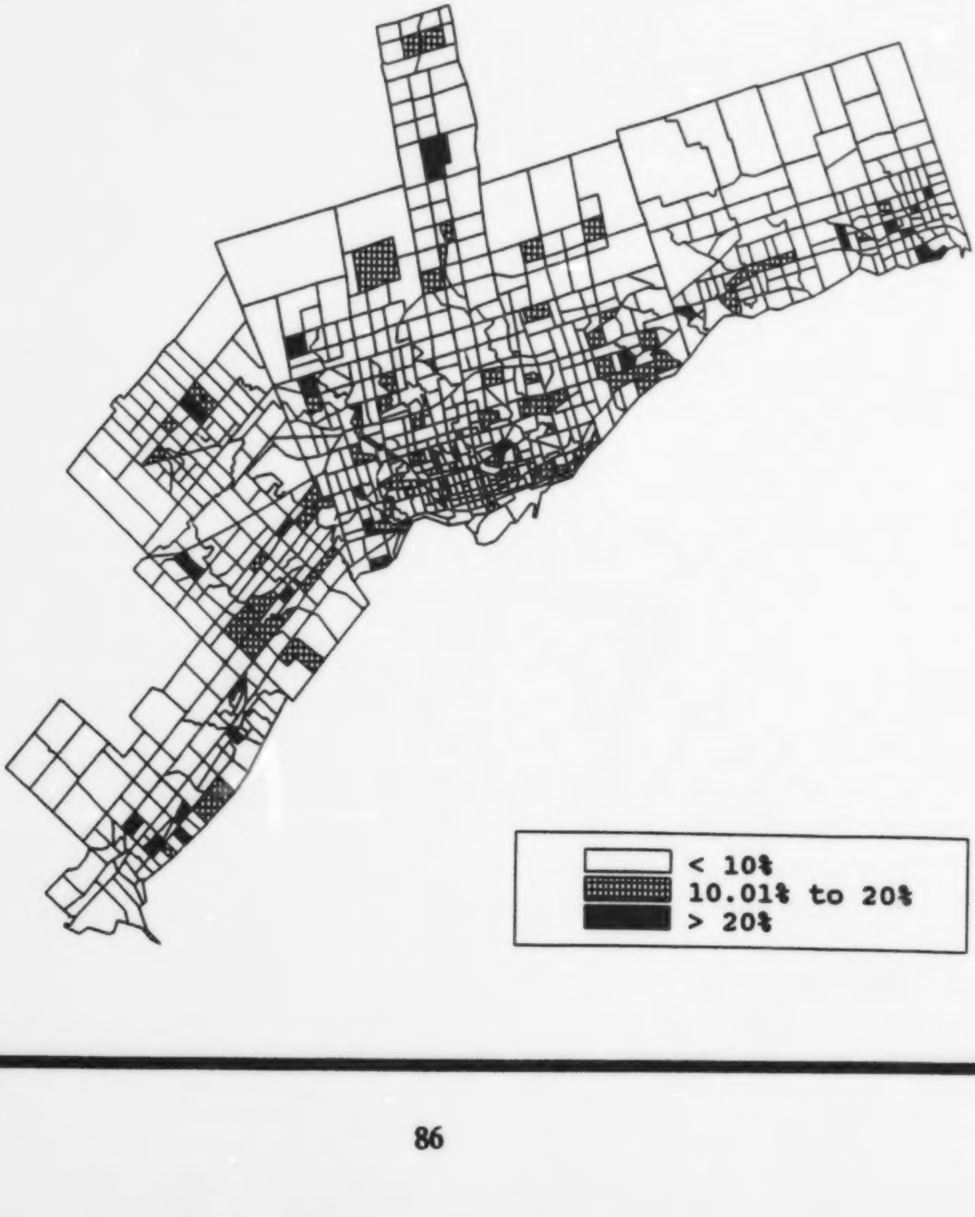


Figure 5.37

Proportion of Trips destined to PD1 within the Inner GTA
home-to-work trips, by transit

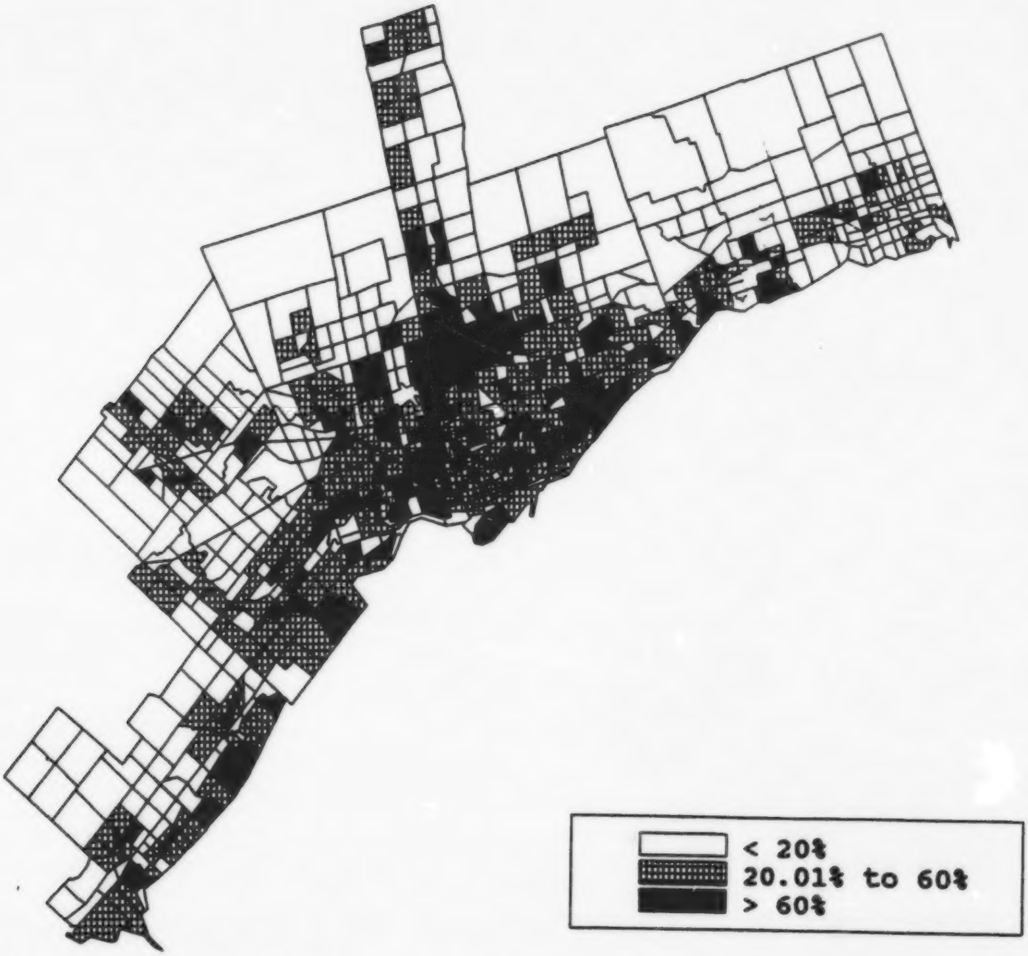


Figure 5.38

Southwest Durham Region Mode Split
home-to-work trips, destined to PD1

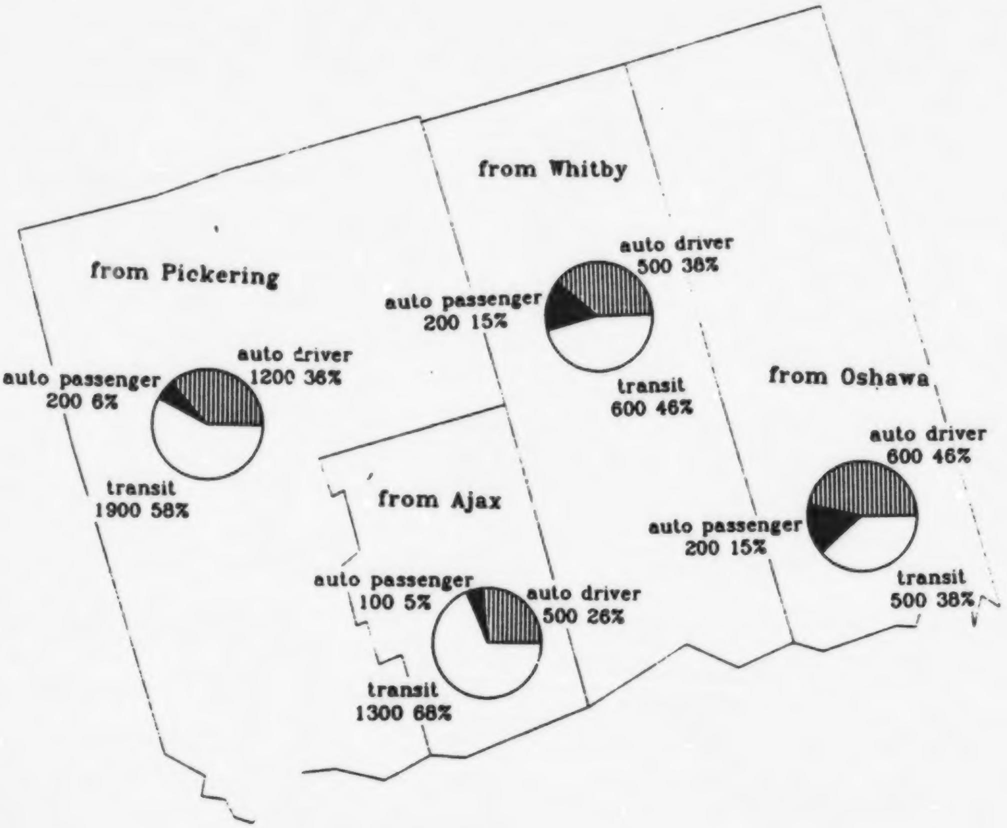


Figure 5.39

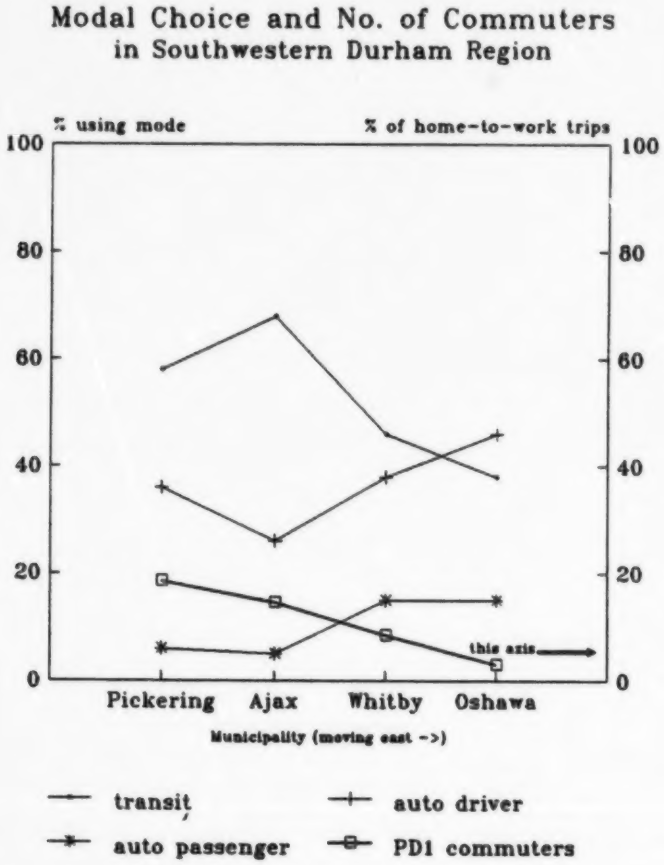

Modal Choice and No. of Commuters
in Southwestern Durham Region
% using mode
% of home-to-work trips
100
80
60
40
20
0
100
80
60
40
20
0
this axis
Pickering
Ajax
Whitby
Oshawa
Municipality (moving east ->)
transit
auto driver
auto passenger
PD1 commuters

Figure 5.40

from the Metro Toronto border the number of commuters travelling to Planning District 1 declines rapidly. Concurrently, transit use declines and the use of auto-based modes increases. Thus a relationship seems apparent between the number of commuters and the use of transit to travel to the central area. Even though fewer commuters come from Ajax, they are much more transit dependent than their neighbours to the west in Pickering.

In York Region the overall values are similar to the other regions. Significant local variation does not seem to be based on proximity to the city, as was the case in Durham. The municipality-based analysis shown in Figure 5.41 is also somewhat misleading as the various urban communities in Markham and Vaughan show quite different choice behaviour. Modal splits by community in southern York Region are presented in Figure 5.42.

The Thornhill area, which is north of Steeles Ave. between Hwy.404 and Dufferin St., which is immediately north of the Willowdale area in North York and is divided between the Towns of Markham and Vaughan, continues the high transit use trend seen in Willowdale. Approximately 62% of the central area commuters use transit, which is similar to Willowdale. This is likely a result of the higher quality GO bus service in this area and the large park and ride lots at the Finch subway station. This higher transit use extends into the Milliken area where 60% use transit. Highway 404, which is adjacent to this community, seems to have little effect on modal usage.

The north Yonge communities of Richmond Hill, Aurora and Newmarket generate values that approach the regional averages. That is, one-half of PD1 commuters use transit and 40% are auto drivers. These areas are served by GO bus and train services.

Finally, to the northeast and northwest significant differences are evident. In Markham-Unionville and Woodbridge transit use declines significantly. While Markham-Unionville is twice as PD1 dependent as Woodbridge (13% vs. 6%), the auto driver mode in both communities is an uncharacteristically high 61% while transit is only 30%. This is one of the lowest values for any major community in the GTA. Factors involved in this low

York Region Mode Split
home-to-work trips, destined to PD1

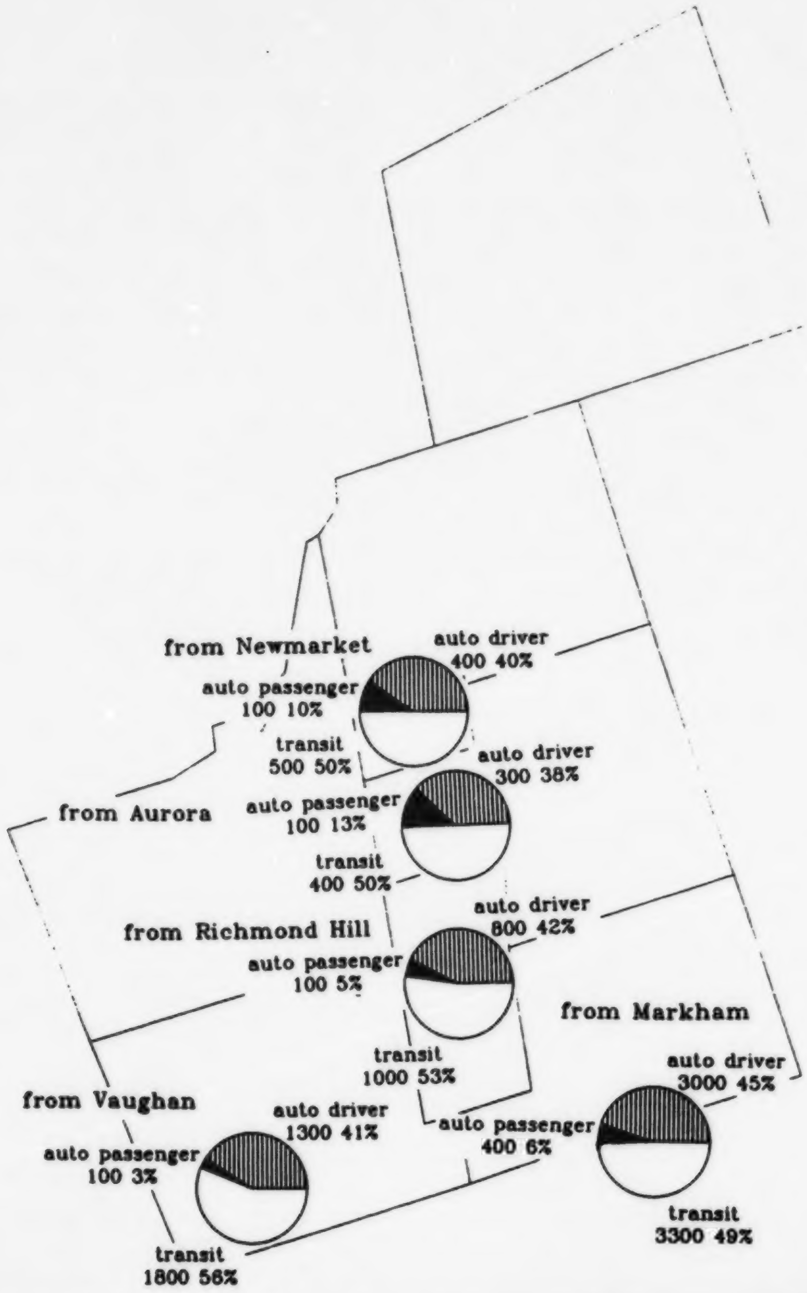


Figure 5.41

Southern & Central York Region Mode Split

home-to-work trips, by community, destined to PD1

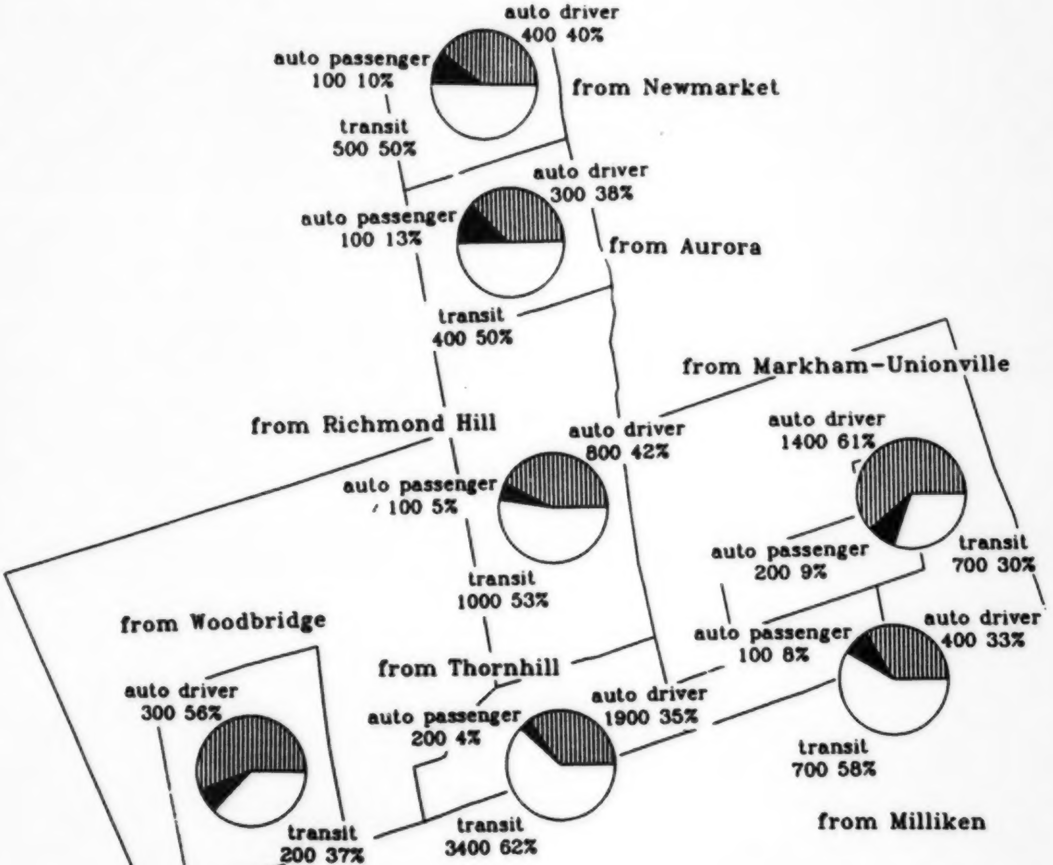


Figure 5.42

mode split may be the distance from the nearest subway station, limited GO Train service (one train per day) and relatively close access to Highway 404 in the east and Highway 400 in the west. A tendency to higher incomes in the two areas may also be a factor in explaining for this behaviour.

In conclusion, within York Region transit trips to PD1 are generally concentrated in the Yonge St. corridor and along the Metro border to the east. Outside of these areas the auto-based modes are dominant.

In Peel Region the modal split tends to show limited spatial variation. West of the Metropolitan Toronto border (and single fare TTC service) there is a drop in transit use to approximately 50%. This value remains relatively constant across Mississauga. Even in Brampton, which is physically separated from Mississauga and has quite different modal opportunities, the mode split is similar to that in Mississauga. Figure 5.43 indicates modal splits for the three municipalities in Peel Region while Figures 5.36 to 5.38 indicated the spatial variations in mode choice.

In Halton Region a more distinct spatial pattern is evident. In the northern urban areas in Georgetown and Milton, both of which are served by limited GO Train service, the transit mode split is below the regional average of 50% (Figure 5.44). The number of commuters is also relatively small and the PD1 interaction limited. In Burlington only two spatial factors are apparent. First, there is a concentration of transit users near the Burlington GO station, (since 1986 a second station has been built at Appleby in eastern Burlington). Second, the area north of the QEW which is in a more remote location is, as expected, dominated by auto based modes.

Transit usage in Oakville is particularly high at 60%. The areas adjacent to the Clarkson, Oakville and Oakville West GO Train stations show mode splits as high as 70%. Transit usage in Oakville, which is 35 km from PD1, is similar to the values for Etobicoke or Scarborough which border the City of Toronto. Two factors may account for this shift to transit use. Faced with a long drive on the QEW and Gardiner Expressway, which is the

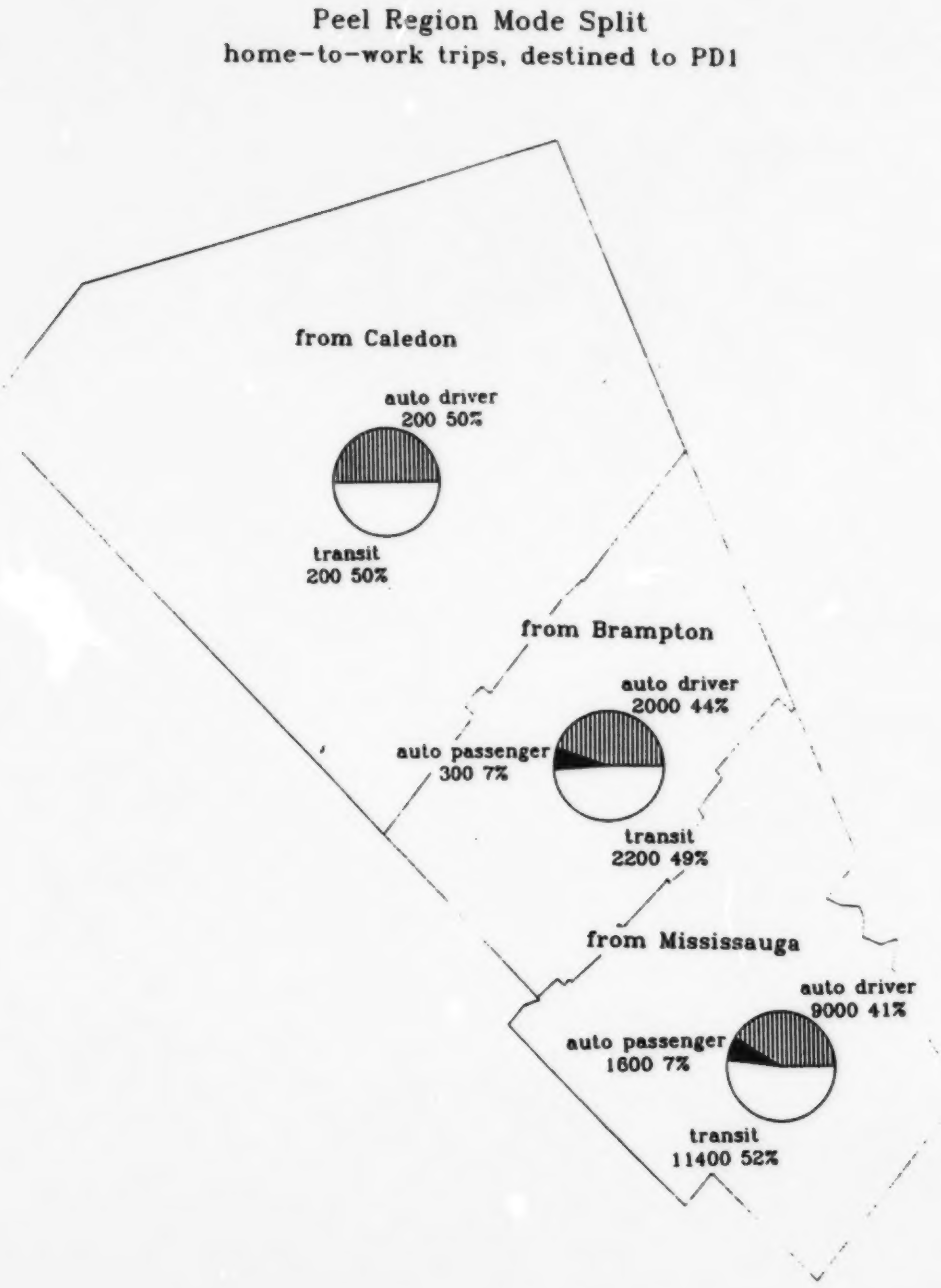

Peel Region Mode Split
home-to-work trips, destined to PD1
from Caledon
auto driver
200 50%
transit
200 50%
from Brampton
auto driver
2000 44%
auto passenger
300 7%
transit
2200 49%
from Mississauga
auto driver
9000 41%
auto passenger
1600 7%
transit
11400 52%

Figure 5.43

Halton Region Mode Split
home-to-work trips, destined to PD1

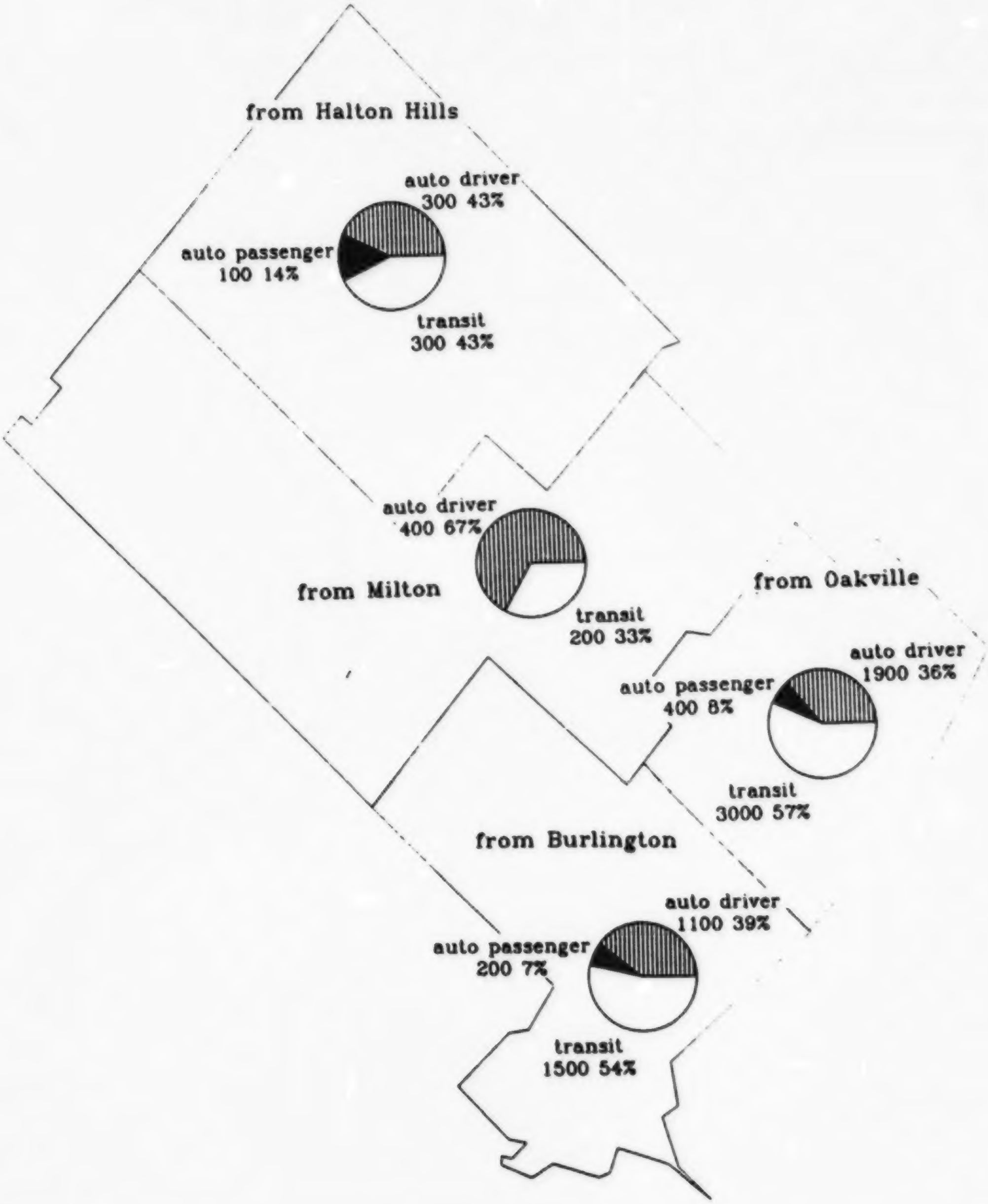


Figure 5.44

primary auto route, many commuters find the high quality transit service more attractive. Secondly, much of the residential development in the area has been specifically targeted at the wealthy, downtown commuter market by focusing on the advantages of using the GO Train. Thus Oakville's PD1 dependency of 16% of the home-to-work trips is the third highest of any municipality outside of Metro. Only Pickering at 19% and Markham at 16.1% show higher values.

In conclusion, results outside of Metro vary in each direction. In the east, results show transit use declining with distance. In the north more varied results are evident. High transit use occurs near to the Finch Station and the Yonge Street corridor and extremely low values are evident elsewhere. In the west, results are spatially ill defined except for a higher transit shift in Oakville. Highways have little spatial effect except for the Don Valley Parkway. There are only two major highways into the central area, however, and one parallels the Lakeshore West GO Train line making comparisons between road and transit corridors difficult.

Many of these modal features can be seen in the analysis of modal trip distances for commuters to Planning District 1, which are presented in Figures 5.45 to 5.47. As previously noted, the distribution for workers' trips who work in PD1 has a double peak. The peak is more pronounced in the transit distribution than the auto driver distribution. This is due to the large, remote transit zones in the northeast and west. The first larger peak of the distribution represents the significant numbers of commuters who live in the denser areas nearer the city centre. The more common use of auto-based modes with increasing distance from the central area causes the auto distribution to have a trough that is 12 km away from PD1 as opposed to 11 km for the transit mode.

Beyond 21 km transit use abruptly declines. At this distance 90% of the transit trips have been accounted for (Figure 5.48). This includes most trips within Metro Toronto and thus the sharp decline beyond the influence of the TTC can be seen. The remaining transit trips are GO Transit and regional transit users and represents a much smaller market.

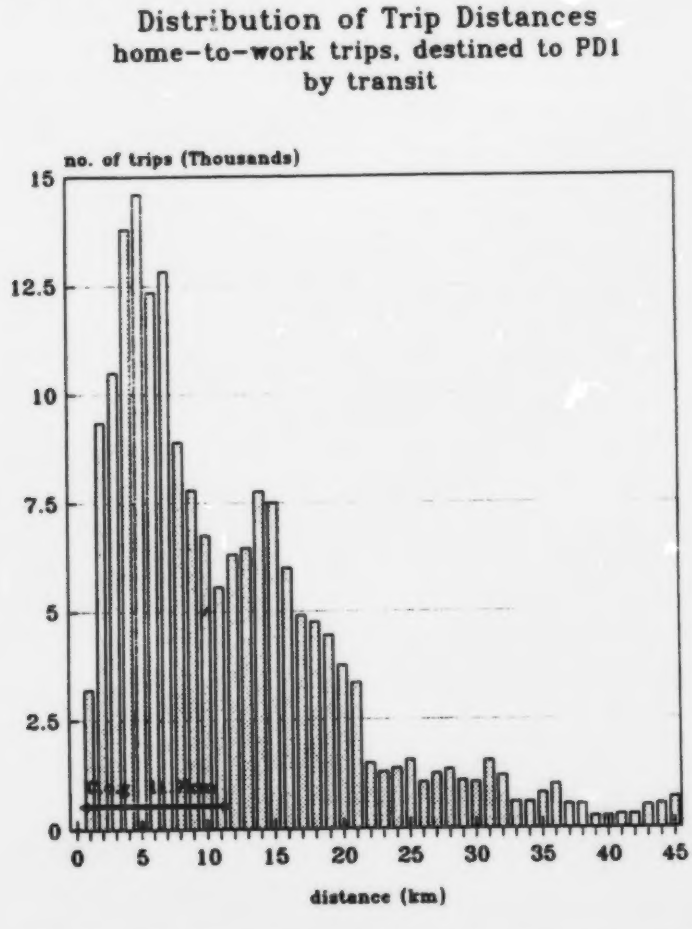
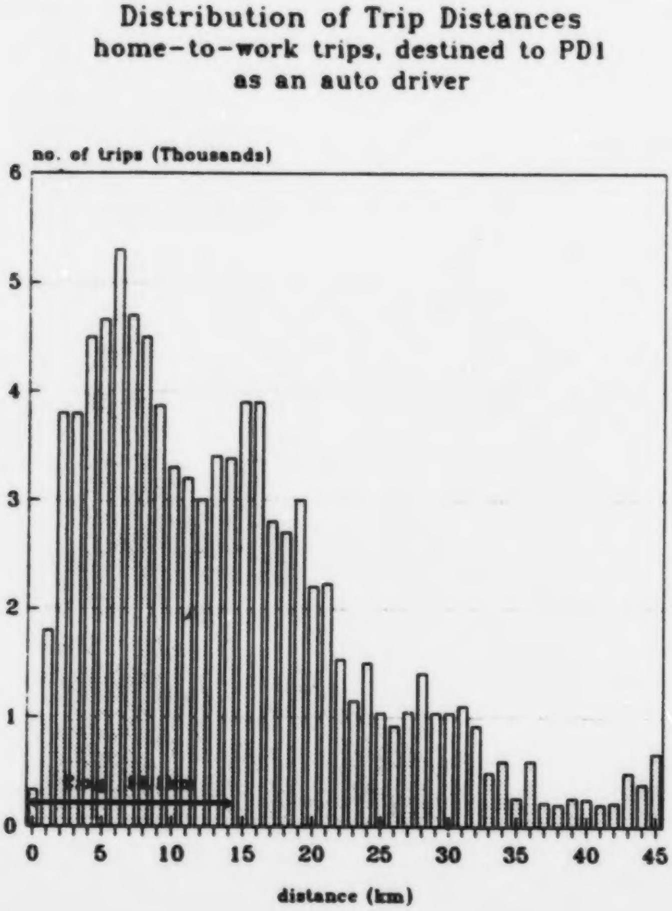
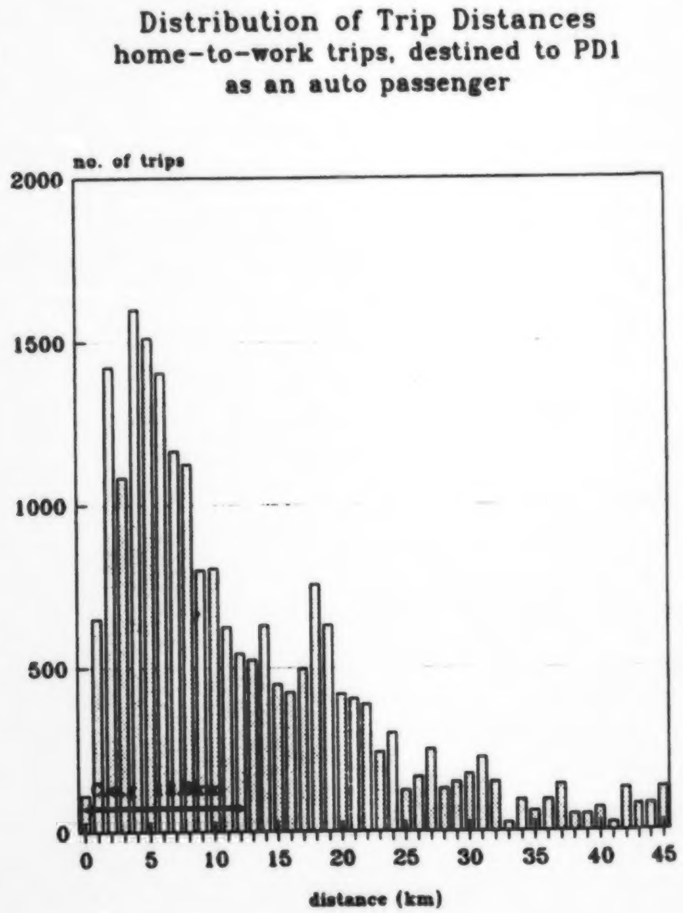

Distribution of Trip Distances
home-to-work trips, destined to PD1
by transit
no. of trips (Thousands)
15
12.5
10
7.5
5
2.5
0
0
5
10
15
20
25
30
35
40
45
distance (km)

Figure 5.45



Distribution of Trip Distances
home-to-work trips, destined to PD1
as an auto driver

Figure 5.46



Distribution of Trip Distances
home-to-work trips, destined to PD1
as an auto passenger

Figure 5.47

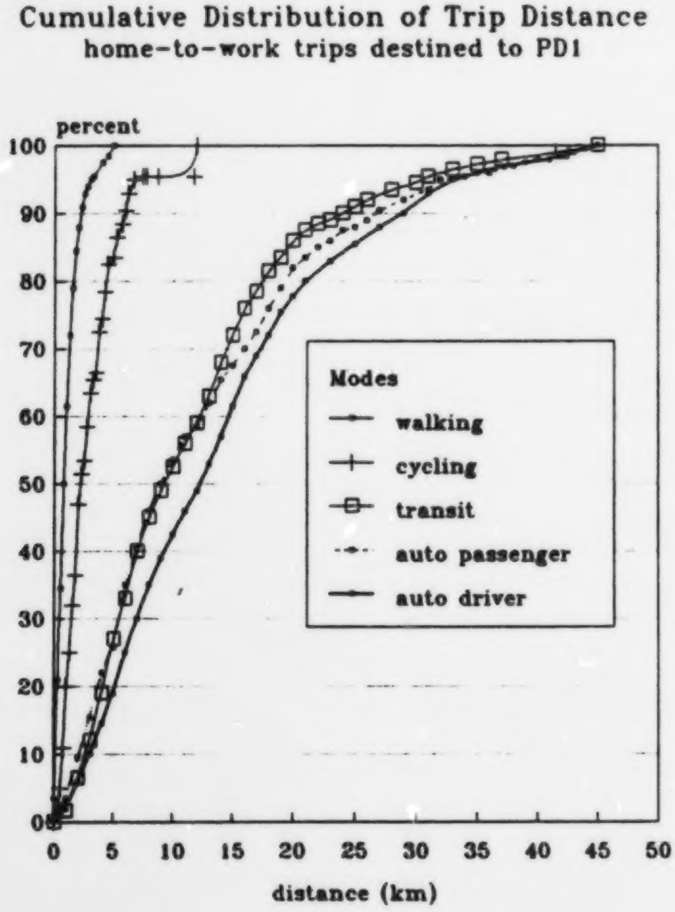

Cumulative Distribution of Trip Distance
home-to-work trips destined to PD1
percent
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
50
distance (km)
Modes
walking
cycling
transit
auto passenger
auto driver

Figure 5.48

Most of the regional transit riders to PD1 are transit choice riders, as 91 to 96% of these users have driver's licences (Table 5.1). This is compared to the 80% of the Metro Toronto, central area workers who have licences and the 75% of the City of Toronto, central area workers who have driver's licences. Within Metro Toronto and Peel Region central area workers are less likely to have driver's licences than non-central area workers. In the other regions both sets of workers are just as likely to have driver's licences (Table 5.1). The extensive Metro transit system and a more mature Mississauga transit system evidently allows this choice to be made. The concentration of transit users can also be seen in the smaller centre of gravity for the transit mode than for the auto driver mode (11.7 km vs. 14.1 km) (see Figures 5.45 and 5.46). Finally note that, overall, PD1 workers are willing to commute a much further distance to work than non-PD1 workers. This is a finding that has been documented earlier.

Also of note is the magnitude of the distributions. The absolute numbers of auto drivers who commute to PD1 represent approximately one-tenth of the total home-to-work drivers for the GTA. The vast majority of the daily commuter traffic and resulting congestion thus has nothing to do with the downtown core. By comparison, approximately one-half (57%) of all home-to-work transit users in the GTA are bound for PD1. Of these transit users 25% do not have driver's licences.

Returning to the walk mode, the distribution of trip distances indicates that PD1 workers seem generally prepared to walk up to 2 km to work. The centre of gravity of the distribution is 1.2 km (Figure 5.49) and 95% of these commuters walk less than 3 km (see Figure 5.48). Non-PD1 home-to-work tripmakers generally walk further to work than PD1 home-to-work tripmakers, which likely represents the more diffuse urban network in the suburbs (Figure 5.50). There is little difference between the sexes or among age levels for those who walk to work as the age distributions are similar (Figure 5.51). Finally, one-quarter of all those people who walk to work do so in PD1.

Percent of home-to-work Tripmakers with Driver's Licences

Region	all home-to-work tripmakers	home-to-work tripmakers destined to PD1
GTA	88	81
Metro Toronto	83	79
York	95	94
Durham	95	95
Peel	97	91
Halton	96	96
Hamilton-W.	90	90
City of Toronto	78	75
PD 1	77	73

Table 5.1

Distribution of Trip Distances
home-to-work trips, destined to PD1
walking

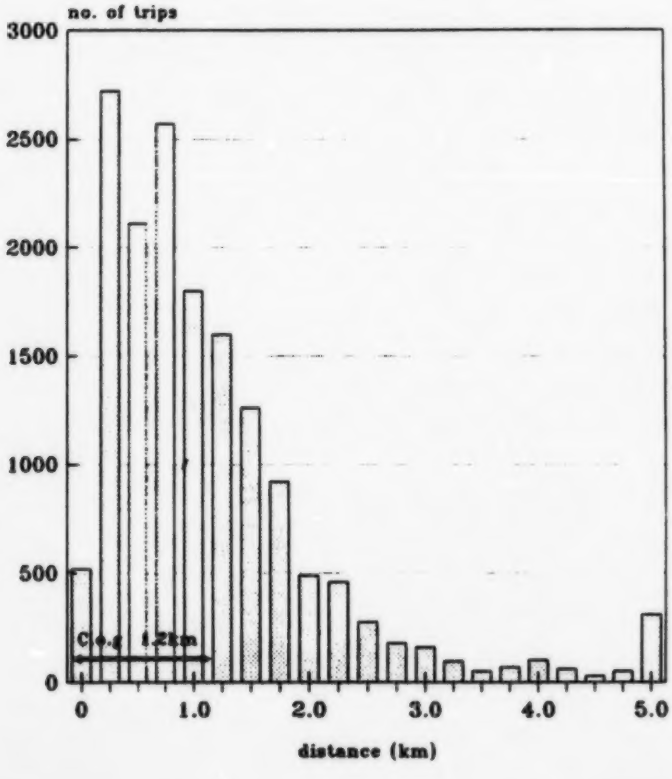


Figure 5.49

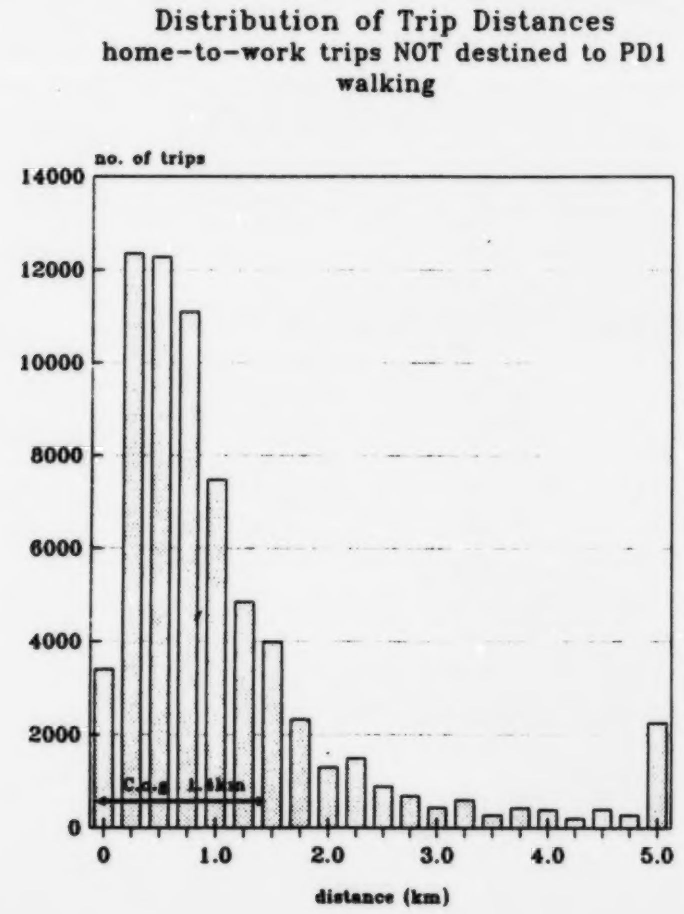
Distribution of Trip Distances
home-to-work trips NOT destined to PD1
walking
no. of trips
14000
12000
10000
8000
6000
4000
2000
0
C.o.g 1.5km
0
1.0
2.0
3.0
4.0
5.0
distance (km)

Figure 5.50

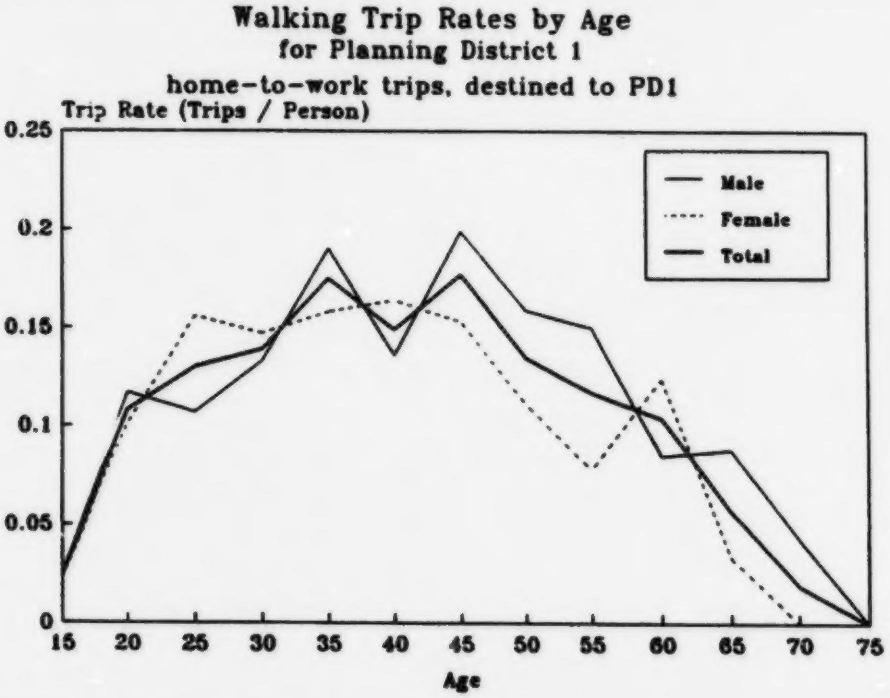

Walking Trip Rates by Age
for Planning District 1
home-to-work trips, destined to PD1
Trip Rate (Trips / Person)
0.25
0.2
0.15
0.1
0.05
0
15
20
25
30
35
40
45
50
55
60
65
70
75
Age
Male
Female
Total

Figure 5.51

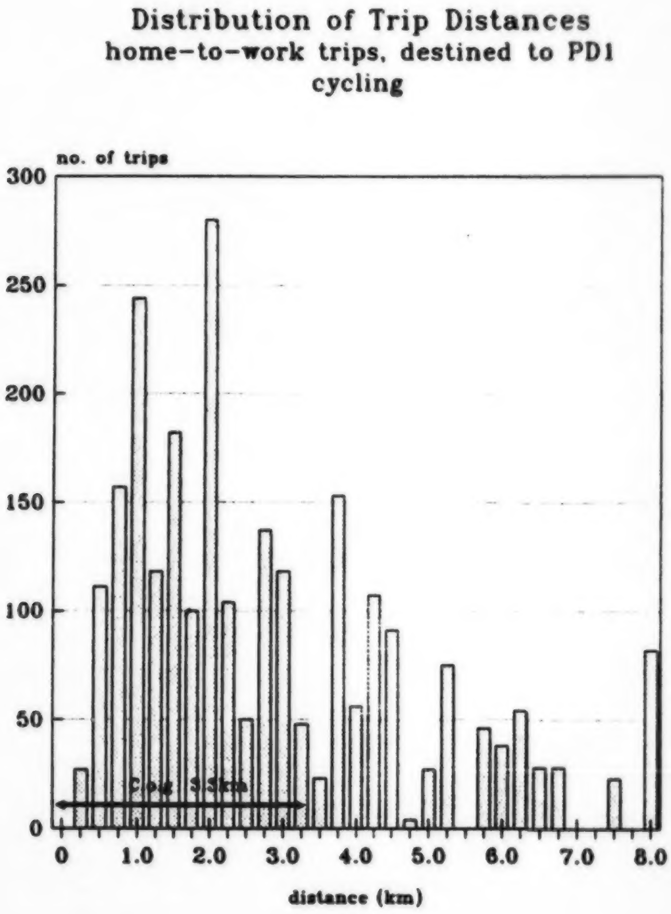

Distribution of Trip Distances
home-to-work trips, destined to PD1
cycling

Figure 5.52

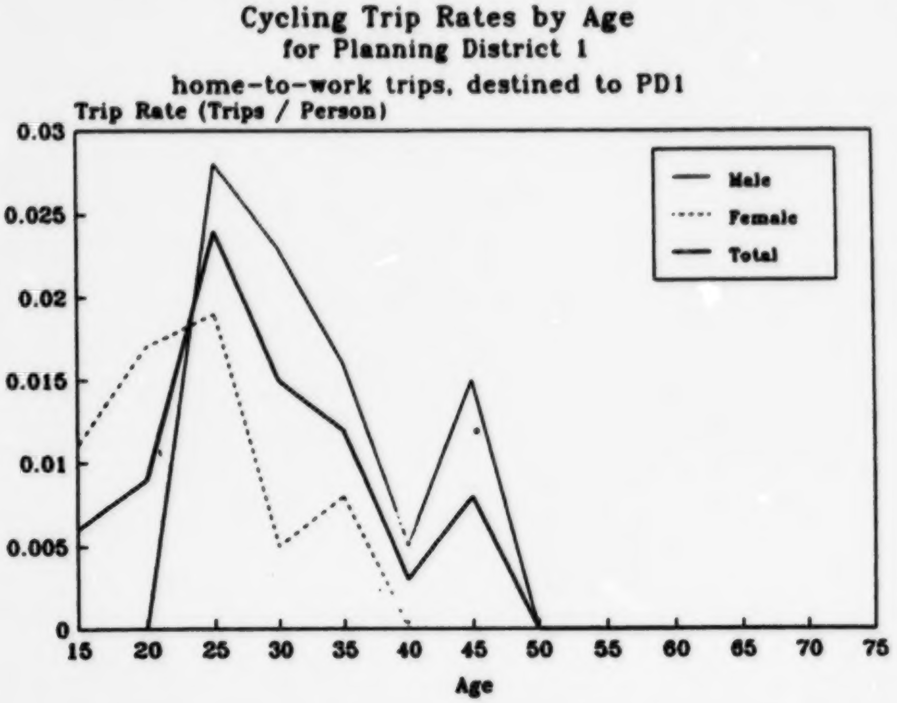

Cycling Trip Rates by Age
for Planning District 1
home-to-work trips, destined to PD1
Trip Rate (Trips / Person)
0.03
0.025
0.02
0.015
0.01
0.005
0
15
20
25
30
35
40
45
50
55
60
65
70
75
Age
Male
Female
Total

Figure 5.53

The results for the cycle mode are small and erratic, but the centre of gravity for the distribution is about 3.3 km and 95% cycle less than 7 km (Figure 5.52). The peak ages for the use of this mode are approximately 27 years for men and 22 years for women. In the peak years men are 50% more likely to use this mode than women. After each of the peaks the popularity of this mode of travel declines rapidly (Figure 5.53).

5.6.4 GO Train/TTC Transit Mode Choice

Two primary transit properties operate into the central area of Toronto. GO Transit's conventional, heavy rail commuter trains operate on six routes into Union Station in downtown Toronto. The TTC, which is the local transit provider within Metropolitan Toronto, operates a heavy rail subway, streetcars and buses into the downtown. The two roles of the properties are different but overlap in several areas. Even though the TTC generally operates within Metro Toronto it has some routes that operate beyond Metro's borders into the surrounding municipalities. These services are contracted by those municipalities. There is an additional fare associated with crossing the Metro border on any TTC vehicle. Large park and ride parking lots have also been built at the terminals of the subway lines so that many regional, and local, commuters can drive to these stations. Several regional transit properties also feed their service into the subway. Mississauga Transit operates into the Islington subway. GO Transit buses from Milton and Guelph, Georgetown and Brampton connect to the Yorkdale subway. GO buses from northern Yonge St. and Markham and Vaughan Transit buses feed into the Finch station.

To analyze transit riders into Planning District 1 by property, three categories were created. A GO Train user is defined as someone who takes the GO Train during any part of his/her trip to PD1. This assumes that once a rider boards the GO Train he/she will take it all the way to Union Station. A TTC user is defined as one who takes a TTC bus, subway or streetcar during any part of the trip and does not use the GO Train during the trip. It should be noted that many GO Train users board the TTC subway at Union and ride it north to work. These people were only considered to have been GO Train users. Thirdly, "others" are considered to be people who use neither the GO Train nor the TTC during any part of their trip. This category includes people using the GO Bus "CityLink" services between Hamilton and Toronto, private carriers and VIA Rail.

The GO Train service is generally a highly discretionary service. Only 8% of the users for home-to-work trips to PD1 are captive to transit because they do not have a driver's licence (Table 5.2). This is consistent with earlier findings. [Miller and Steuart, 1981] The portion of the GO Train's home-to-work market without driver's licences varies from 11% in Metro to 5% in York Region. Also note that 99% of the home-to-work trips made using the GO Trains are destined to downtown Toronto.

Conversely, the TTC is a far more significant service for transit captives. Thirty percent of its home-to-work riders do not have drivers licences (Table 5.2). This figure is heavily weighted by the 38% of transit users without licences in the City of Toronto. Regionally, only 18% of TTC users are captive to transit.

Each region has a substantially different transit property mode split (Figure 5.54). Overall, the TTC carries 87% of the 186,000 home-to-work transit riders in the GTA destined to PD1. GO Trains carry 13% or 23,000 riders and 1% or 1600 riders use the other modes (Figure 5.55). It should be noted that the GO Train service is only 20 years old and has quickly grown to become a significant factor. By observing the five regions outside of Metro, the significance of the GO Train becomes more apparent. Fifty-eight percent of transit based commuters travelling from outside Metro use this mode while 38% (12,200 trip makers) choose to use the TTC (Figure 5.56).

Within Metro Toronto the TTC is completely dominant and carries 97% of the transit riders. Spatially, GO Transit only affects a few areas, as seen in Figure 5.57. These areas include the Long Branch and Mimico communities of southwest Etobicoke on the Lakeshore West GO line and Weston and Rexdale on the Georgetown line (both of these values are relatively small). Several hundred commuters board at stations on the Richmond Hill line in North York but the number is minuscule in comparison to the immense numbers moved by the TTC to the subway from these areas. A similar situation occurs at

Percent of PD1 destined, home-to-work, Transit Tripmakers with Driver's Licences

Region	GO Train users *	TTC users *	all transit users
GTA	92	71	75
Metro Toronto	89	70	71
York	95	88	89
Durham	94	95	93
Peel	92	77	86
Halton	94	#	93
Hamilton-W.	91	#	81
City of Toronto	#	66	66
PD 1	#	63	63

* see modal definitions within report

# indicates a small sample

Table 5.2

Regional Transit Property Split
home-to-work trips, destined to PD1

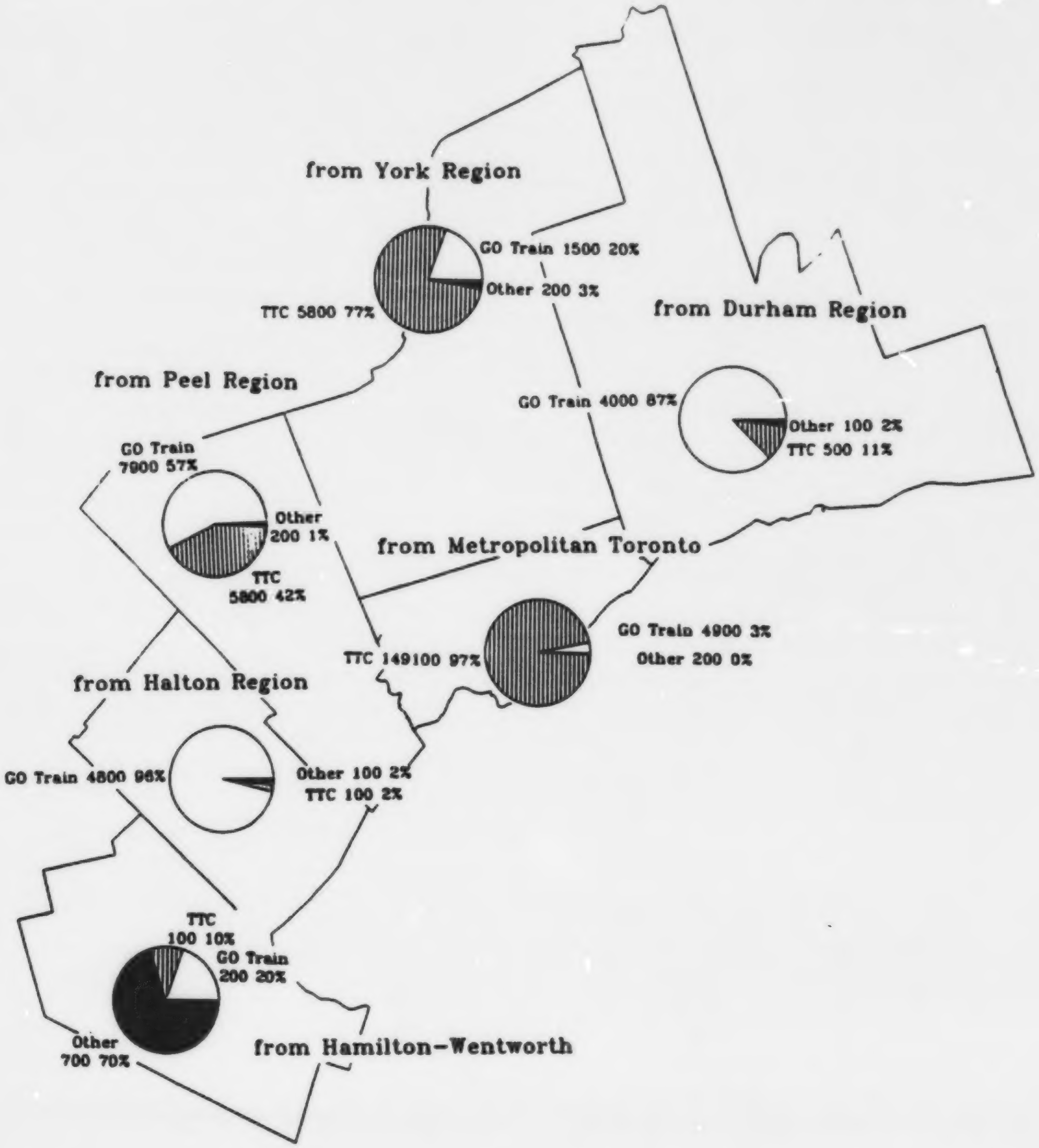


Figure 5.54

Transit Mode Split for the GTA
home-to-work trips, destined to PD1

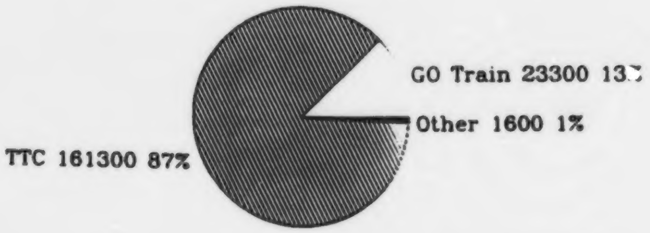


Figure 5.55

Transit Mode Split for the 5 Regions
home-to-work trips, destined to PD1

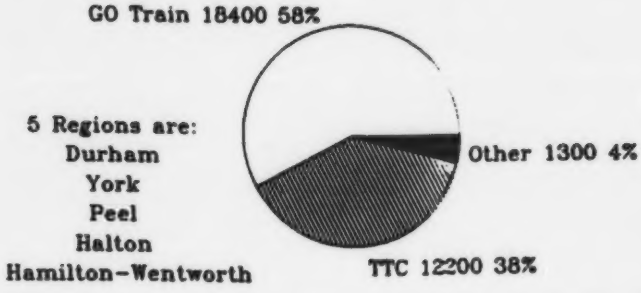


Figure 5.56

Proportion of Transit Trips destined to PD1 within Metro Toronto
home-to-work trips, using the GO Train

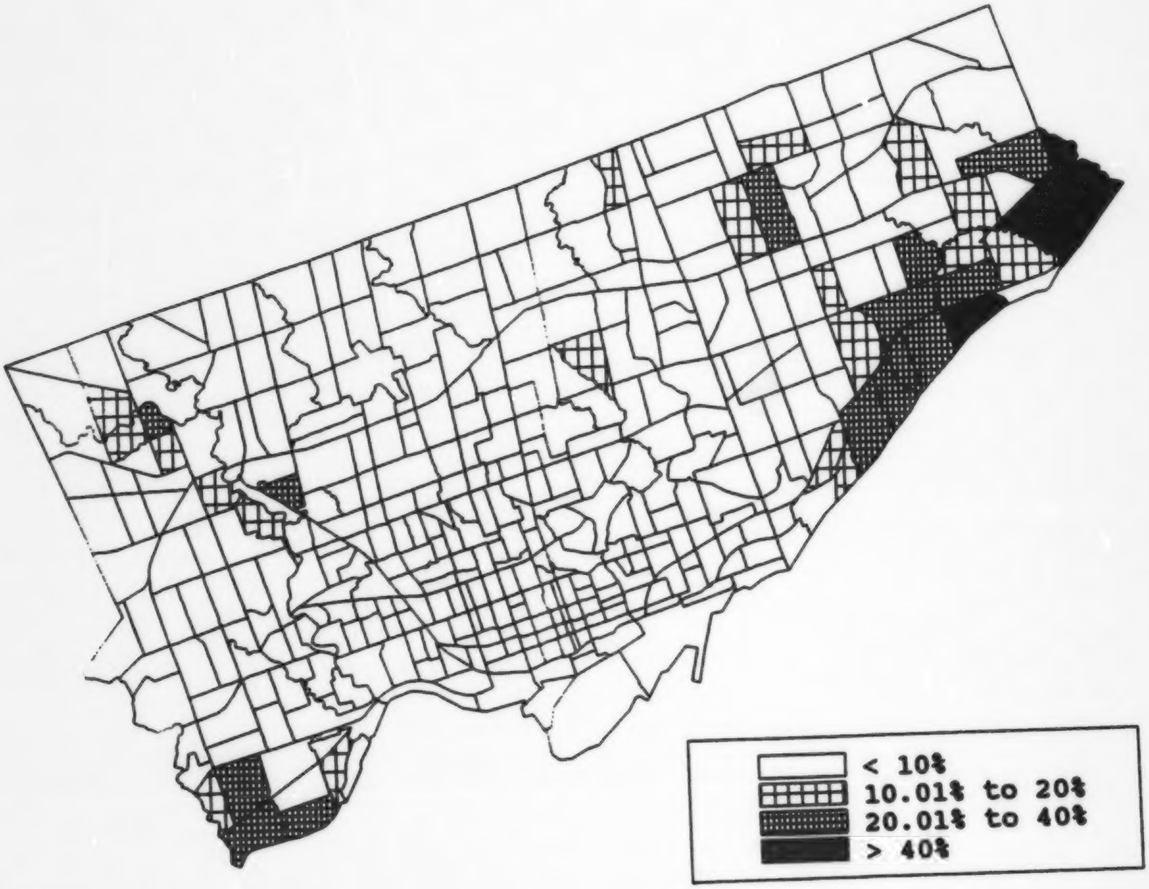


Figure 5.57

Metropolitan Toronto Transit Property Split
home-to-work trips, destined to PD1

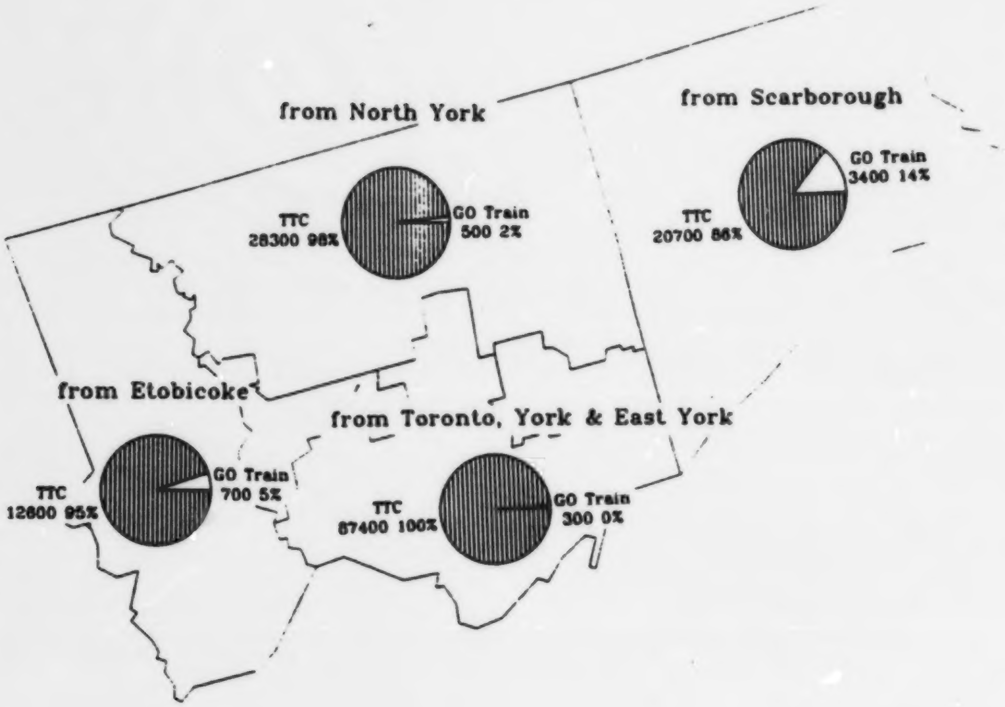


Figure 5.58

Proportion of GO Train Transit Trips generated by each Region

home-to-work trips, destined to PD1

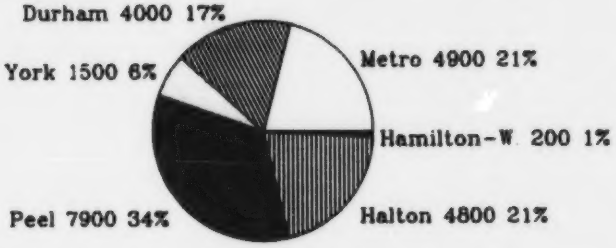


Figure 5.59

Proportion of TTC Transit Trips generated by each Region

home-to-work trips, destined to PD1

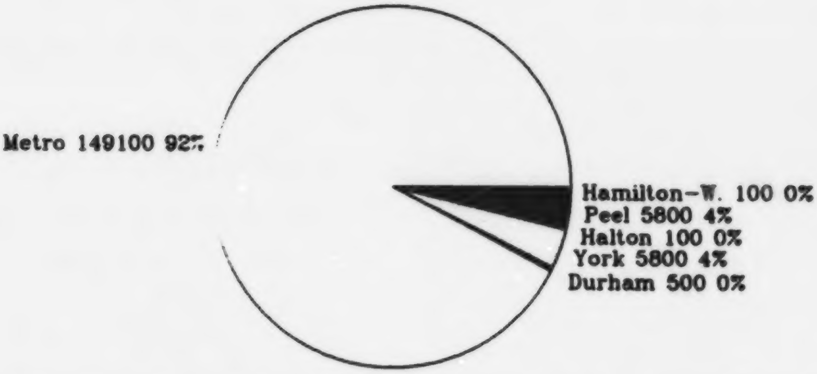


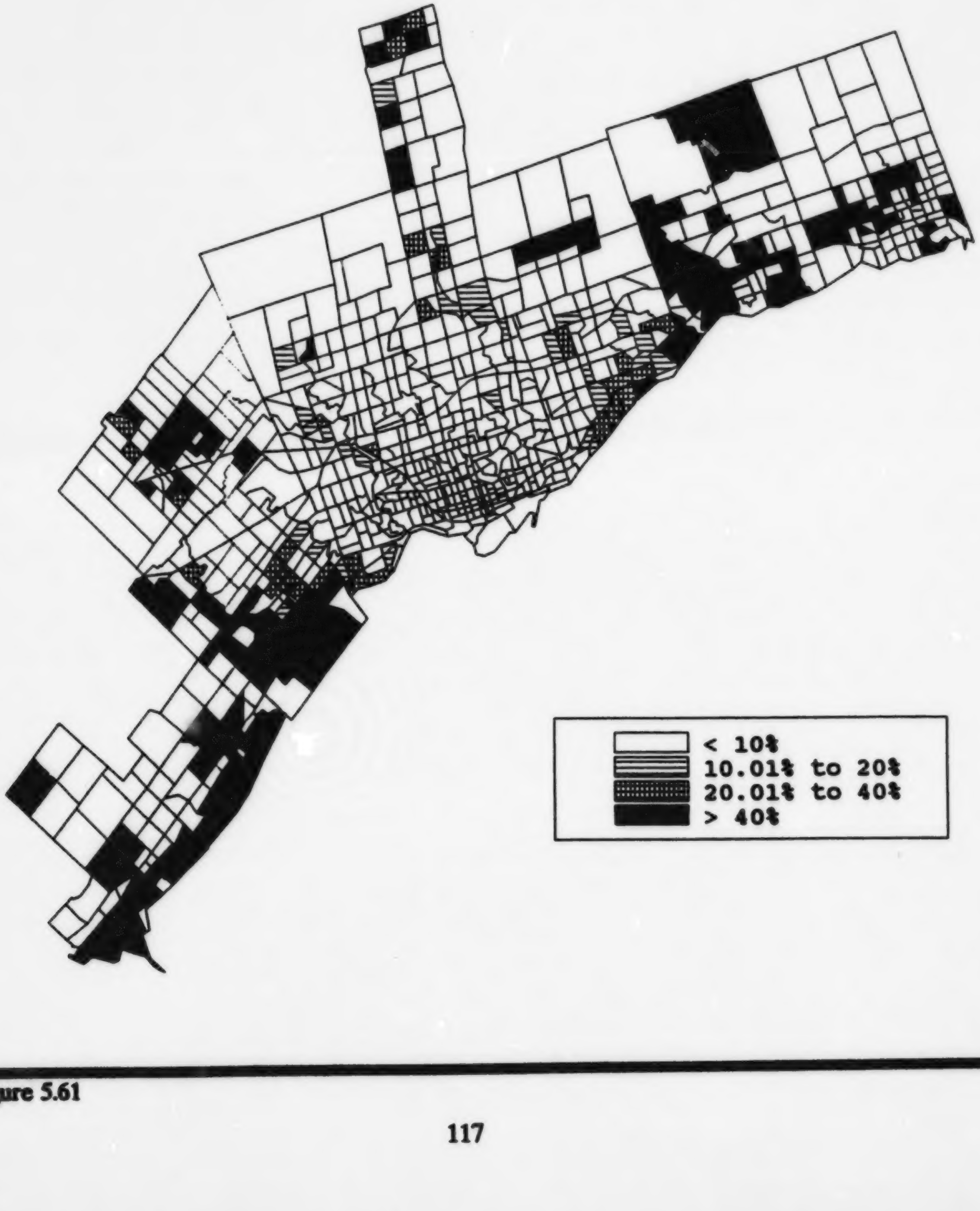
Figure 5.60

the Agincourt station, which is on the Stouffville line, in north Scarborough. The only situation within Metro Toronto where more people take the GO Train than the TTC occurs in southeast Scarborough where there are four stations on the Lakeshore East line. Overall 14% of transit users in Scarborough use this mode or 3400 riders (Figure 5.58). Besides this corner of Scarborough, the GO Trains carry few Metro commuters. Metropolitan Toronto nevertheless produces 21% or 4900 riders of the GO Train's total home-to-work ridership (Figure 5.59). This is the second largest share of any of the regions. This implies that the few commuters taking the GO Train in Metro make up a significant share of the GO Train market, but have an insignificant overall impact on the TTC. Over 90% of the commuters who use the TTC reside within Metro Toronto (Figure 5.60).

Outside of Metro the situation varies. The spatial distributions of GO Train and TTC usage for home-to-work trips to PD1 are presented in Figures 5.61 and 5.62, respectively. In Durham, GO Train service is the dominant transit mode with 87% of transit commuters or 4000 trips. This is 17% of the total GO ridership. This share has definitely expanded with the expansion of GO Train service in Durham in 1988. Limited access to the TTC services by Durham residents is indicated by the small, 11% (500 trips), that are TTC based even though the region is adjacent to Metro.

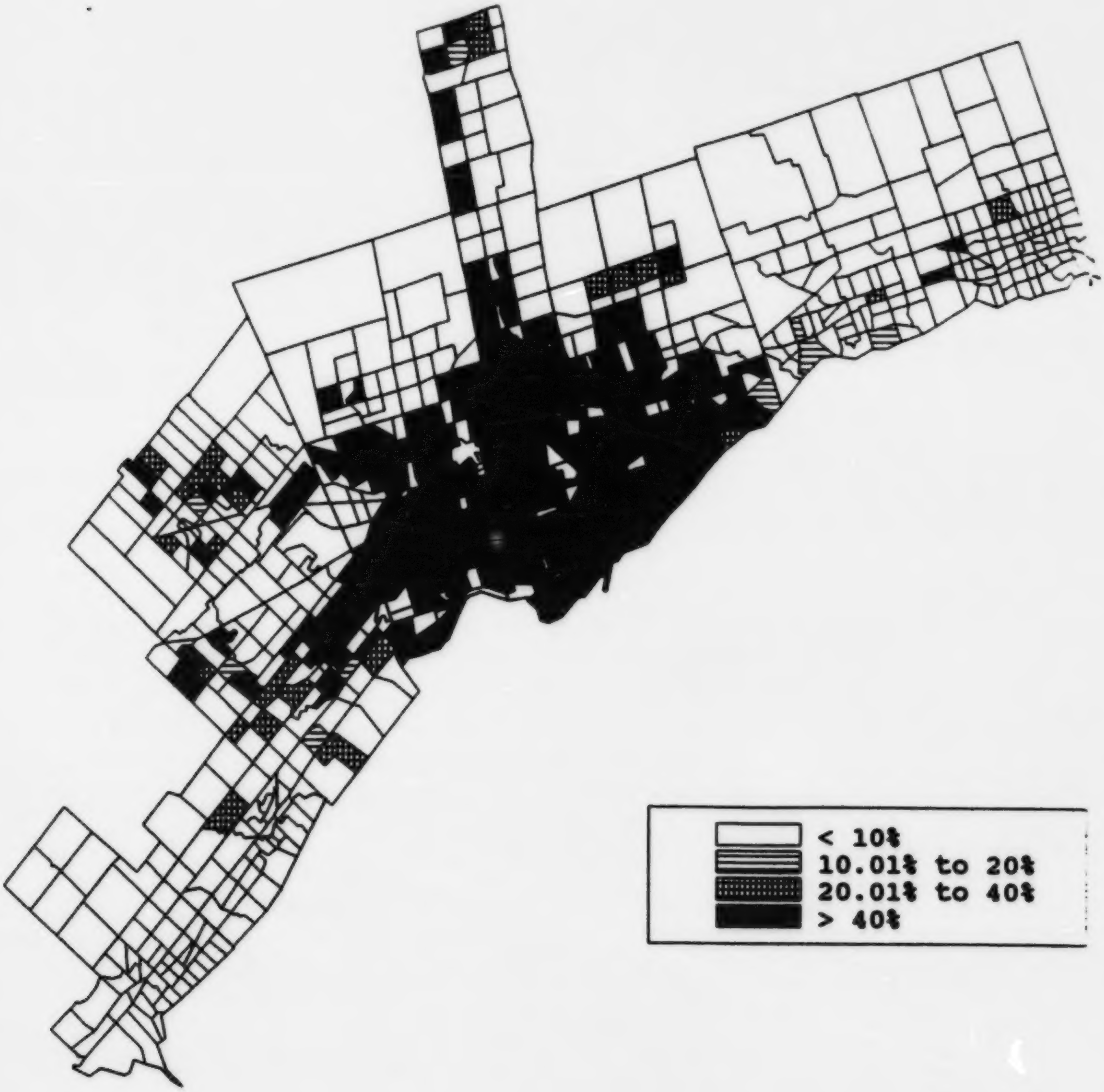
In Halton there is a similar situation in which almost all transit commuters use the GO Train. The region produces 4800 trips or 21% of the GO Train market. This represents 96% of the regional transit trips to PD1. The principal GO Transit market is Oakville.

Further west in Hamilton-Wentworth an unusual result occurs. Only 20% of the transit commuters use the GO Train, although the sample is a relatively small 200. Most of the commuters, 70%, use the GO Bus "CityLink" services rather than the three daily GO trains (see Figure 5.54). The bus travel time, even at rush hour is scheduled to be only 13 minutes longer than train service. The bus also directly serves more of the residential area of downtown Hamilton and travels through downtown Toronto to the bus terminal thus



Proportion of Trips destined to PD1 within the Inner GTA
home-to-work trips, using the GO Train

Figure 5.61



Proportion of Trips destined to PD1 within the Inner GTA
home-to-work trips, using the TTC

Figure 5.62

Peel Region Transit Property Split
home-to-work trips, destined to PD1

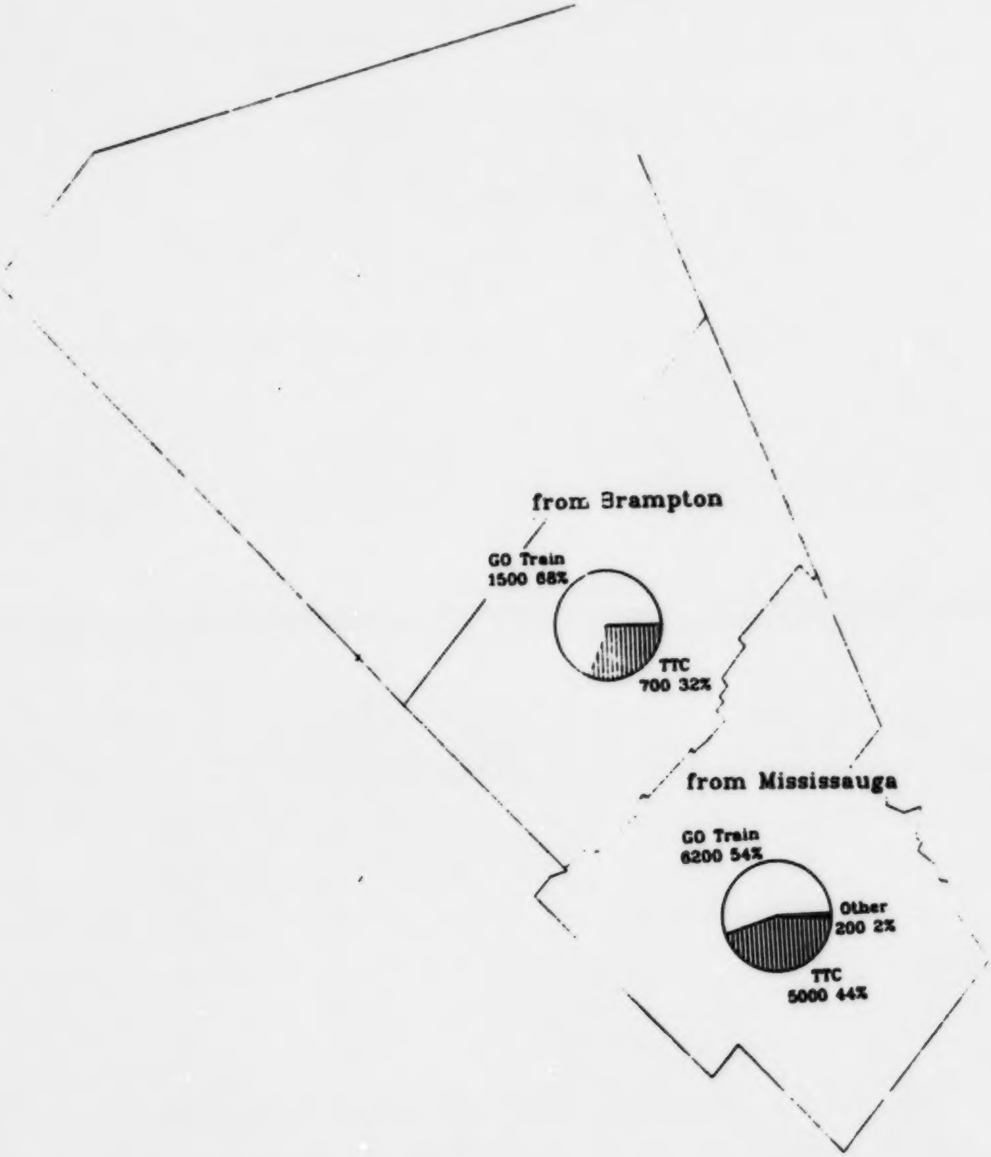


Figure 5.63

reducing the need to use the TTC (at an additional fare). Regardless, Hamilton only represents one percent of the GO Train system ridership.

In Peel Region the situation is again quite different. GO Trains carry 57% of commuters as opposed to the 42% carried by the TTC. This is the largest single GO train market representing 34% of the total ridership. In Brampton one-third of the transit riders destined to PD1 use the TTC (Figure 5.63).

In Mississauga a definite spatial division occurs in a diagonal line across the city from the Mavis Rd. and Eglinton Ave. area to the Dixie Rd. and the Queensway area as seen, again, in Figures 5.61 and 5.62. West of the line the GO Train is dominant and carries more than 60% of the market. To the east of this line the TTC is dominant and carries more than 60% of the market. Overall the municipality is approximately evenly split between the two modes. Fifty-four percent use GO Trains and 44% use the TTC. A substantial portion of Mississauga Transit's vehicles travel to the Islington subway station, which is evident in the eastern half of the city. It is also likely popular to drive to the subway rather than the GO station as the subway provides more frequent service and at a lower fare than the GO Train.

Finally, in York Region to the north, the situation is reversed. The TTC is dominant, carrying 77% of the transit riders versus 20% (1500 riders) on the GO Train. This represents only 6% of the GO Train's ridership. This is expected because the three GO Train routes to the north only operate between one and three peak period trains a day. The GO Train only carries the majority of the transit commuters from Newmarket (50%) and Markham-Unionville (60%) (Figure 5.64). York and Peel are the only regions contributing significant numbers of central area commuters to the TTC. They generate 8% of the total PD1, home-to-work, TTC ridership which is evenly split between the two.

In conclusion, the TTC market shed is clearly defined in Metro, west central Mississauga and south and central York Region. Beyond these borders the GO Train is the dominant central area, commuter transit mode. The diversion of TTC users to the GO

Trains in Metro or south York Region is significant to GO Train patronage but has only marginally changed the huge demand for TTC service.

York Region Transit Property Split
home-to-work trips, destined to PD1

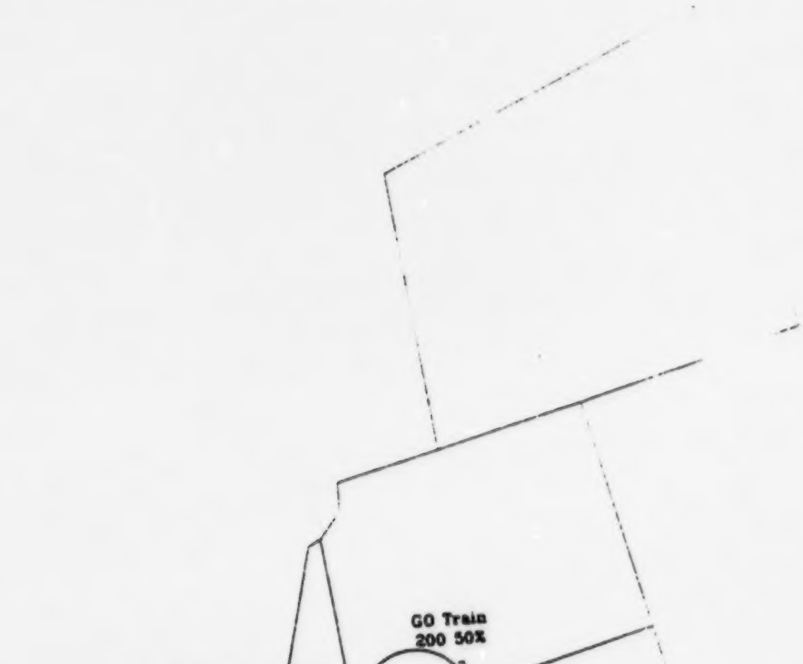


Figure 5.64

CHAPTER 6

DISCUSSION OF RESULTS

6.1 Comparison of Empirical Findings and Theory

The spatial patterns of central area work trip dominance presented in the previous chapter can be related to the theoretical models reviewed in Chapter 2. It is not the principal purpose of this report to develop a theoretical model of such dominance. Nevertheless recognizing the similarities between the GTA and the various proposed structures can aid in the comprehensive understanding of travel patterns within the city. The models of urban structure discussed in Chapter 2, were based primarily on a few simple concepts. First, workers tend to minimize travel cost in terms of time and distance. Some central area workers are also drawn from throughout the urban area. Finally, as a result of both of the previous hypotheses, central area workers are apt to be clustered about the central area.

The most general and powerful of the models examined was the gravity model. It stated that as distance or travel time increases, the propensity for a worker to commute to a location should decrease. This is only the case in some parts of the GTA. Within the central area, there is a significant cluster of workers around the area, as this model would predict. Outside of this area the "T" shaped pattern tends to invalidate gravity principles when they are based solely on distance. The zonal proportion of workers destined to the central area is not decreasing with distance and in many cases it increases. A spatial distribution of travel time would likely show more of a typical gravity distribution. In this case the proportion of trips destined to PD1 would likely decline with increasing travel time in more of a regular pattern. Travel time would be a more reliable variable than distance for the gravity specification due to the presence of subways, commuter rail lines and highways which theoretically provide greatly improved access but only in certain locations. Regardless, travel time would probably only partially explain the exaggerated pattern which is displayed.

Principles beyond gravity model theories appear to be evident within Metropolitan Toronto. The gravity model does not explain the low central area interaction from the northwest and northeast. Thus, alternate theories must be examined in detail. The gravity model does predict a clustering of central area workers around the downtown and therefore it can be used with caution for the Greater Toronto Area for central area, home-to-work trips. In the regional municipalities outside of Metro, gravity model principles seem generally to be more relevant. In most cases there is a decline of work trip interaction with the central area of the City of Toronto as distance or travel time increases.

Carroll's concept of a declining central area work trip propensity with distance is also not completely valid. Carroll's second assumption states that the central area should dominate the residential distribution of workers in an urban area. Strong corridors of PD1 orientation within Metro encourages an even greater densification within these corridors. This allows more of the downtown workforce to live near to the city centre and in proximity to the downtown access routes. Thus, central area workers can reduce their travel time by living in these zones. An example of this situation is the concentration of high density housing that has been built, and continues to develop, near some of the subway stations. Densification is being encouraged within the "T" shaped pattern by the continuing growth of the central city. Therefore the central area is, to a certain degree, affecting the residential distribution of homes within the urban area.

The concentric ring theory proposed by Park and Burgess which predicts that commuters will move to the exterior of the urban area is not particularly valid within Metropolitan Toronto. The preceding discussion indicates that the central area workers are not avoiding the central area. Rather, they appear to be migrating into this area over time. The central area commuters are also not locating in concentric rings. Similarly, Babcock's proposal to modify these concentric rings by distorting them according to the transportation infrastructure is only slightly more applicable. Infrastructure is unmistakably having some affect in the GTA but Babcock's theory fails when he still predicts that central area workers will favour a residential distribution in the outer layers of his model.

In the southwestern municipalities of Durham and in Mississauga the concentric ring theory perhaps seems more credible. This theory would partially explain the banding of these communities. With the possible exception of Oshawa, these communities are not, however, the traditional urban centres for which the model was developed. This theory was not originally meant to be applied to one sub-centre with respect to commuters going to another primary centre. Nevertheless these communities may be showing some of this pattern of an outer ring of affluent commuter housing followed by inner rings of lower income housing and a transition zone. The two inner zones would not be predicted to be dependent on the central area employment of another municipality for employment. At the centre of this local pattern is the somewhat older centre of this town or city. This centre would be likely still be young and small in comparison to the age of the primary city's central area.

Hoyt's sector theory seems the most applicable model to the GTA. This model states that housing which is most amenable to central area workers will radiate away from the central area according to the transportation infrastructure. This seems to be extremely relevant. This can be seen in the three arms of the spatial distribution of home-to-work trips destined to PD1. Meanwhile, industrial sectors or lower income sectors are to be found in the northwest and northeast. The railway lines to the northwest and northeast would account for industry in these locations discouraging high income housing. Therefore lower income housing would tend to be placed in the residential zones within these areas. The residents of this housing would be less dependent on the central area for work than in the other sectors. Similarly an industrial zone along the railways in south Etobicoke would explain the decline in central area workers between the Long Branch and Centennial areas of the municipality. The higher central area worker orientation along the subways and Don Valley Parkway would reflect a residential premium in these sectors encouraging middle and high income housing and central area workers.

The differences between "growing" and "stable" suburbs suggested by Prevedouras and Schofer is again only partially valid in Toronto's case. Many of the inner neighbourhoods in Toronto match their description of "stable" suburbs and have a high level of transit use and central city dependence. There are still, however, many rapidly growing suburbs in the GTA with similar high PD1 dependence. This lack of complete explanation can be seen in some of the stable suburbs in North York and East York and in growing areas of Oakville which all have high transit use and PD1 dependence.

In conclusion, gravity principles are only partially accurate for the Greater Toronto Area. While they explain some of the local variation they do not capture many of the spatial trends. Hoyt provided the most applicable model for the distribution of home-to-work trips to the central area of Toronto. The distributions appears to be in sectors matching the location of much of the transportation infrastructure. A second potential explanation for the higher central area dependence in the bands around some of the satellite suburbs could be the concentric rings of higher income housing around the older communities which was suggested by Park and Burgess.

The Greater Toronto Area does not seem to be affected to the extent of Vancouver by natural or developmental borders (recall Figure 2.2). The spatial variation of central area dependence generally flows continuously across the urban area. Some influence of this effect can be seen at political borders such as Steeles Ave. to the north. The effect of such boundaries, however, is not overwhelming.

The central area workers within the GTA seem to be more concentrated than in the Philadelphia area. Eighty percent of these commuters live within Metropolitan Toronto whereas in Philadelphia 50% live in the eight outer counties. The mode split between the two urban areas are almost identical. Each value is within plus or minus five percent in both urban areas. This provides limited data for a generalization of either city but does suggest that the central area mode split in Toronto is typical of large urban centres in North America which have a full range of transport options available.

6.2 Policy Implications

The central area of Toronto continues to be the single most important employment centre in the Greater Toronto Area. Twenty percent of the resident GTA labour force work in this approximately 20 km^2 area. The residences of these workers are spread throughout the urban area. This report has examined the spatial distribution and modal choices of these workers as of 1986. Implications arising from this analysis with regards to the future of transportation in the region can be divided into three transportation markets: the City of Toronto, the rest of Metropolitan Toronto, and the five other regional municipalities.

6.2.1 City of Toronto Issues and Options

The City of Toronto is the largest single municipality of residence for central area workers. This is fortunate in that it reduces the overall spatial demand for transportation services by decreasing work trip commuting distances. Recent local policies have been effective in this area. The employment provided by the central area is also generally compatible with City residents, which is also a positive development. Toronto residents among all working age groups are finding employment in the central area. These workers are also residing in most parts of the City. Therefore the transportation problems associated with the central area are, to a significant degree, originating within the City of Toronto.

The policy adapted in the mid 1970's which encourages residential development in the central area has mitigated some of the impact of the increasing transportation demand. Walking to work, which involves minimal impact on the transportation network, is the single largest mode of transport within Planning District 1.

Some of the commuters in the City, however, have much less of a benign effect on the transportation system. Twenty-five thousand city residents who work in the central area are still driving downtown. This is one in four of all of the workers who drive to the central area. (The second of the four comes from one of the five regions surrounding Metropolitan Toronto and the final two of the four are from the rest of Metro Toronto.) Efforts to discourage these travellers from using their cars could have a major effect on the level of traffic in the City. Previous studies have indicated that many people feel they "need" their vehicles during the day and thus feel obligated to drive to work. It is doubtful, however, that all 20% of the City residents who drive their car to work in PD1 are within this category.

While transit in the city carries a large percentage of the commuters and provides the most comprehensive service in the GTA, it is still possibly missing part of the market. Attempting to more directly address the needs of local residents, particularly in the east and north ends where the percentage of auto usage is high, could have a real effect on the level of traffic. Potential measures would likely not be as capital intensive as other infrastructure improvements in the GTA but could remove a significant amount of traffic from the City's streets. These measures could include dedicated, peak period express buses into the central area, scheduled "short-turn" services on long routes designed to provide additional capacity within the City, transit priority on certain routes (in particular, streetcar routes), and additional transit service in the east end of the City.

A second alternative that could lead to reduced traffic levels would be to encourage even more people to live within the City. The City's central area housing policy reduces traffic levels by encouraging more people to live extremely close to work and thus be less auto-dependent. The areas where the residences of central area employees are concentrated generally follow the City's borders. Thus, encouraging housing anywhere in the city allows workers who work in the central area to live closer to work. This also takes advantage of the existing transit infrastructure.

Although some of these new City residents would likely continue to drive to their central area jobs, the overall result would still be in fewer cars in the downtown area, since commuters living outside of the City are much more likely to drive than those who live within the City. The transit system would also be in place if these new City residents could be enticed into not using their cars. The possibility that the proportion of workers using transit could be increased would be even greater because the higher residential densities would make transit more efficient to provide. It should also be noted that the auto drivers in the City of Toronto probably use a more dispersed set of routes than do regional auto

auto commuters, since they are not as dependent on the high capacity highway corridors as the regional commuters tend to be.

6.2.2 Metropolitan Toronto Issues and Options

In Metropolitan Toronto, other issues are apparent. Metro contains more of a mix of areas that are and are not dependent on PD1. Defined spatial trends in dependency and mode choice are evident. Metro Toronto also contains the majority of central area commuters and is faced with expensive capital expenditures to meet their needs. In particular 75% of the auto drivers and 85% of the transit users who travel to work in Planning District 1 live within Metropolitan Toronto. Various policies could be implemented to diminish the overall transportation impact of these commuters.

Densification of residential land use has several potential advantages. The central area dominates much of the residential distribution in the municipality through the "T" distribution mentioned earlier. Encouraging high density housing at higher transit use locations within this distribution would decrease the likelihood that new PD1 commuters would drive downtown. This would again take advantage of the existing infrastructure. This means bringing people to the transit system rather than the more expensive policy of bringing transit to the people. Thus, new central area commuters would live in developing high transit nodes. This policy would attempt to stop people from being forced to use their cars by promoting locations that reduce the necessity of auto use.

Conversely, the Don Valley Corridor seems to be encouraging auto use. New developments in this corridor may be as auto-oriented as the existing housing for trips to the central area. Thus the further intensification of residences in this corridor may intensify auto use. The presence of the highway, regardless of how congested it is, may simply encourage more auto use. While the Don Valley area is not traditionally known as an area of poor transit service the DVP seems to be far more attractive to the central area commuters than the local transit service. This phenomenon continues into the north side of the 401 in Scarborough. Policies to improve the competitiveness of the transit system, relative to the auto, should be examined in this corridor. In particular, improvements to the transit system in this corridor should be pursued prior to any significant intensification of land usage within the corridors.

The desirability of the presence of the "U" shaped area where a much lower proportion of central area workers live must also be considered. The central area is the only location that is attracting a significant number of choice transit riders. Thus it is the key market that allows more than minimum transit service to be provided in many areas. If a larger number of the growing central area workforce resided in the northwest and northeast they would thus be more likely to take the transit system to work than the present population who work in other locations. Consequently they would form a base transit market on which the service in these area could be expanded, which, in turn, could potentially entice riders to use transit to travel to other locations as well. The social desirability of having such clearly marked work orientation borders in Metro should also be examined. This is not directly a transportation question but could be influenced through transportation decisions. Hoyt proposed his sector theory several decades ago when social norms were quite different and perhaps now cities should be working to prevent such patterns from evolving.[1]

Improved GO Transit train services may well represent one way to increase transit service inexpensively to areas of lower transit use within Metro. Presently the GO Trains seem to have little effect within Metro, except in southeast Scarborough. Potential does appear to exist, however, for improved GO services (particularly in the Don Valley corridor) to supplement TTC services by providing high-speed, "express" services into the central area.

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[1] The social implications of altering the basic composition of residential neighbourhoods are, of course, complex, and transcend the single issue of transport network efficiency. Given the concerns about the availability of "affordable housing" within Metro, it is not immediately clear that encouraging the movement of generally higher income central area workers into the traditionally lower income blue collar neighbourhoods is, on balance, socially desirable or undesirable. The point being made here is simply that it might facilitate the development of a more efficient transit system, which could yield benefits to the Metro community as a whole.

The TTC system, of course, is the backbone of the Metropolitan Toronto transit system. Although TTC ridership has tended to grow by only modest amounts in the recent past, there is, nevertheless, potential for significant growth in central area work trip commuting by TTC. This is particularly the case if policies such as residential densification at high transit use nodes and the targeting of the 86,000 Metro auto-based commuters are actively pursued. The major challenge in this case may well be how to cost-effectively increase the capacity of transit services into the central area in order to accommodate this potential growth.

6.2.3 Regional Issues and Options

The regional municipalities outside of Metro face a different set of issues. These are rapidly developing areas. Much of the future growth in the GTA will without doubt occur in these regions, although decisions by Metro with regards to densification might affect the rate of this growth. Choices that are made can continue, discourage or increase each region's current level of attraction as a place of residence for central area workers. Linking some of these communities to the central area may involve large capital investments.

Many municipalities are currently dependent on the central area for employment. In much of Oakville one in four workers travels daily to PD1 to go to work. Overall, 16% of these residents work in the central area. The age distribution of these commuters indicates that these people are typically primary breadwinners who are in their peak earning years. Other municipalities are equally dependent on the downtown. In Pickering 19% work in the central area, in Markham 16% and in Mississauga 15%. Economically, the central area is important to many areas as a primary employment site.

Changes in travel patterns as the regions grow should be examined. The present travel patterns indicating propensity to work in the central area may change with time. The evolving distribution may eventually be as distinct as the pattern within Metropolitan Toronto. The new communities that are being developed may not necessarily be linked to the central area to the same extent as today's communities. They may relate to the central area in a unique spatial manner. Such an example may be the proposed North Pickering Development.

In addition, areas that were developed only a few years apart can produce significantly differing relationships with the central area. This may be a function of the rate of employment growth in the central area and the suburbs at the particular time these homes came on the market. Thus, infrastructure decisions that are primarily based on the proposed housing composition or location of a community may not be relevant when the actual residents occupy the area. The evolution of these suburban, central area dependent patterns must also be examined to determine if they are as consistent with time as the patterns within Metropolitan Toronto are likely to be. These are questions for future analysis but will be fundamental to the future of transportation decision making.

The regions produce a number of central area commuters that are almost an order of magnitude lower than within Metro. Only three out of twenty transit central area commuters travel to PD1 from the regions and one out of four auto drivers. Massive residential growth will not suddenly change this situation. Regional commuters use the transportation infrastructure more extensively than Metro commuters, however. They generally use the highways rather than arterial roads. They also spend longer on each link of the transportation system and are funnelled into routes that often have the most acute and chronic congestion problems, such as the Gardiner Expressway.

Infrastructure expenditures to serve the remote communities will satisfy relatively few commuters, but at considerable cost. It is important to consider that, for example, 0.4% of the PD1 commuters come from Oshawa. Even a massive building program that increased the local proportion tenfold would still only represent 4% of the total commuters, if the number of jobs in the central area remained constant. The earlier calculation that a 70% regional transit mode split would remove fewer cars than a minor 5% increase in transit use within Metro again illustrates the point. Policies that create marginal changes in mode split within Metro have vastly more impact than large shifts in the mode split from the regions.

The extension of transit service to outlying areas also encourages the further decentralization of the urban area by allowing more central area commuters to live increasingly further from the city. The growth of the urban area increases the set of housing from which commuters may choose. This, in theory, allows more people to take advantage of less expensive fringe area housing. The infrastructure costs resulting from this decentralization may, however, be prohibitive. More centrally located areas of the city may require new transportation systems concurrently to the needs of the expanding fringe areas. The two different categories of commuters will generally have differing and potentially expensive needs.

Overall throughout the GTA many issues remain to be resolved. If commuters continue to travel to the central city from increasingly distant communities, will it be feasible to continue to extend the transit system to the hinterland while postponing improvements that would affect far more people? Changes in social patterns may also change transit's role. Younger women are the primary socio-economic group presently using transit. As new generations enter the workforce this pattern may not continue. Women who move up the economic ladder may favour private cars to the extent that men traditionally have. This will lead to declining transit usage and increasing auto use. In addition, looking beyond the immediate focus of this study (i.e. central area commuting), the overall future of transit may also be somewhat gloomy, as over half of the home-to-work transit users are going to PD1. Among the remaining home-to-work transit users many are captive to transit because they do not have driver's licences. As the proportion of GTA employment in the central area continues to decline in favour of a far more dispersed regional distribution of employment, transit may become an increasingly less relevant method to solve the overall transportation problem.

CHAPTER 7

SUMMARY, CONCLUSIONS AND FUTURE WORK

7.1 Summary and Conclusions

While the central area of Toronto has declined in importance as a source of employment in the Greater Toronto Area, it still remains a primary employment centre. Twenty percent of all home-to-work trips (321,000 trips) in the GTA are destined to this 20 km^2 area.

The concentration of central area workers, as a percentage of zonal home-to-work trips, exhibits a noticeable spatial pattern throughout the GTA. This indicates defined spatial preferences for central area commuters. These spatial patterns can only be partially explained by standard gravity model concepts. These concepts would indicate declining proportions of workers who choose to work in the central area with increasing travel time or distance. The central area seems, to some extent, to be dominating the residential distribution of workers. A significant proportion of the central area workforce chooses to reside in certain areas relative to the central area. This follows a hypothesis suggested by Douglas Carroll. The most complete theoretical spatial model which describes the residential distribution of workers is the "sector theory" proposed by Hoyt. Industrial zones and lower income residential zones which produce a minimal central area interaction radiate from downtown to the northwest and northeast. Conversely, central area workers tend to concentrate in the north, east and west of the downtown core.

While distinct spatial patterns exist, the proportion of home-to-work trips destined to PD1 by regional municipality is extremely consistent. Approximately ten percent of each region's home-to-work trips are destined to PD1. The exception is Hamilton-Wentworth which presently has a minimal PD1 interaction. Outside of Metro Toronto five municipalities have significantly greater than the average 10% of their home-to-work trips destined to PD1. They are, in order:

Pickering	19%
Markham	16%
Oakville	16%
Mississauga	15%
Ajax	15%

Within Metropolitan Toronto this figure increases to 30%, in the City of Toronto to 50% and within Planning District 1 to 63%. Approximately one-third of the central area workers live in the City of Toronto and increasing numbers are choosing to live in the central area itself.

Approximately 15% of the commuters live more than 21 km from their PD1 employment (measured as a straight line distance) and five percent live more than 31 km from their place of employment.

Young women, approximately 25 years old, have the highest central area, home-to-work trip rate. The male rate peaks at approximately thirty years of age.

Modal choice variations amongst the central area commuters by region indicate that at the aggregate level of the regional municipalities modal opportunities are spatially equal. Distinct differences in mode choices are, however, obvious in a more detailed analysis. The overall mode split and number of trips being made by each mode for the Greater Toronto Area for home-to-work trips destined to PD1 are:

auto driver	30%	(95,200)
auto passenger	7%	(21,500)
transit	58%	(186,100)
walk	5%	(15,800)
cycle	1%	(2500)

Within PD1 the walk mode is the largest single mode of travel to work. Forty percent of the workers use this mode or 14,000 workers. Within the City of Toronto auto-based modes of travel tend to be more common in the east end, while overall 25,000 cars are driven to the central area daily by city residents travelling to work. Cycling registers a minor modal share in all areas of the city, with a 2% model share overall throughout the City.

Within Metropolitan Toronto 60% of PD1 commuters use transit. Auto use is higher along the Don Valley and adjacent to the 401 in Scarborough and Etobicoke. The largest area of consistently high transit use is the Willowdale and northern Don Mills areas of North York. Secondary high transit use areas are in southwest Scarborough and West Toronto. Several highly dependent transit zones have also developed adjacent to several subway stations.

Outside of Metro Toronto the mode splits in most of the regional municipalities is approximately:

auto driver	40%
auto passenger	10%
transit	50%

There are several pockets of higher transit use such as Oakville, Thornhill and Ajax.

Examining the origin of the commuters who arrive in the central area, by mode, three distinct groupings are evident:

- one in four cars entering the central area on home-to-work trips originated within one of the five regional municipalities
- the second of the four cars originated within the City of Toronto
- the final two of the four originated from the rest of Metro Toronto

Similarly for transit users:

- three out of twenty of the transit commuters originated within the five regional municipalities
- seven of the twenty from the City of Toronto

- the remaining ten from the rest of Metropolitan Toronto

Transit captivity, due to not having a driver's licence, increases with decreasing distance from PD1.

- fewer than 1 in 10 regional transit commuters are captive
- one in five Metro Toronto transit commuters are captive
- one in four City of Toronto transit commuters are captive

GO Train users are generally choice riders while 30% of the TTC's riders are captives.

The TTC also carries 87% of the transit riders to PD1 for home-to-work trips, while the GO Train carries most of the remaining 13%. There is a definite spatial division in transit property usage. This is with the exception of within Metro where the GO Trains obtain 20% of their riders from areas where generally most commuters still use the TTC.

The general policy implications of these findings are that transportation problems involving work trips to the central area can, at present, largely be addressed by looking at issues within the inner areas of the GTA. Small percentage changes in modal splits can have significant results in the number of automobiles using the roads. Several areas, particularly within Metro Toronto have relatively low rates of public transport use for trips to the central area. Addressing the transit needs of these areas could dramatically reduce road congestion in the central area.

Additional measures to curb the demand for roads to the central area include the densification of land uses at high transit use nodes. This is already occurring and possibly should be encouraged further. Finally, the "U" shaped distribution of areas where a lower proportion of central area workers reside may be an inefficient use of land. This distribution could potentially be broken down by transport initiatives. This would make more land within Metro attractive for central area workers and thus encourage the evolution of a more efficient transit network.

7.2 Future Study

To more completely understand the implications of these patterns it is essential that this work be repeated in a few years with new data (e.g., the proposed 1991 TTS update) and examine the differences that have occurred. This will provide a more profound understanding of the transportation needs in the GTA and provide some insight into how relationships with the central area are evolving. If the rate of growth in the central area declines, the spatial patterns may change. As a result of this decline the "T" shaped distribution could deteriorate or decay. Mode choice may also be altered by declining PD1 dependence in the City, Metro Toronto or the regions. Equality of opportunity could alter female mode choices and trip rates.

In any future transportation study additional work should also be done with regard to auto passengers. Little is know about this mode. The choice mechanisms and the reasons for the consistency of the values across the GTA remain unclear. The mix of informal and formal car pool formation should be investigated. This could lead to plans to encourage a more efficient use of auto pools to reduce the number of cars in the central area.

A second area needing more examination is the cycling mode. The results reported in the TTS are quite erratic. There is a need for a better profile of the users of this mode. Perhaps cyclists should be surveyed at a time of the year when cycling is more popular. In addition, the modal choices of these commuters when they cannot cycle due to the weather should be examined.

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